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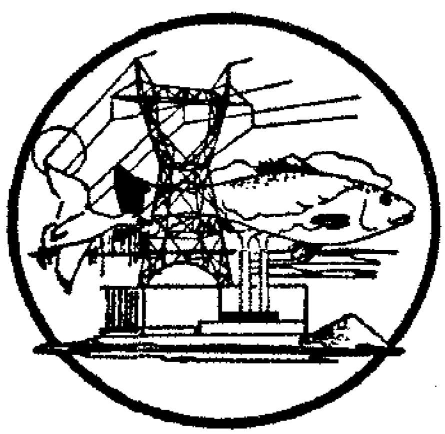
Biological Services Program

DEVELOPMENT OF FISHES OF THE MID-ATLANTIC BIGHT

AN ATLAS OF EGG, LARVAL AND JUVENILE STAGES

VOLUME III

APHREDODERIDAE THROUGH RACHYCENTRIDAE



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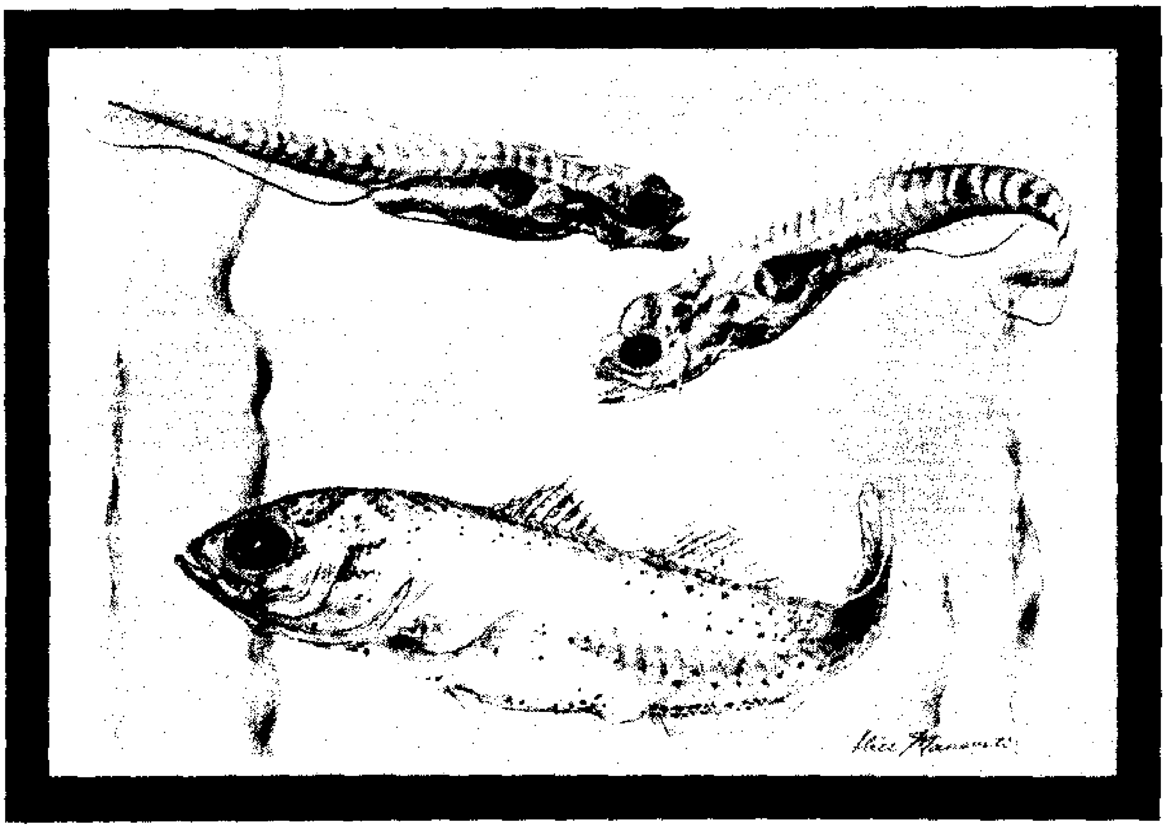

Larvae of the striped bass, *Morone saxatilis*. (Original illustration by Alice Jane Mansueti Lippson.)

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APHREDODERIDAE THROUGH RACHYCENTRIDAE

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Performed for
Power Plant Project
Office of Biological Services
Fish and Wildlife Service
U.S. Department of the Interior

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FOREWORD

The demand for electric energy often creates conflicts with the desire to preserve and protect the Nation's fish and wildlife resources. This is particularly true when the use of water for power plants is considered. Power plants require large volumes of water from rivers, lakes, reservoirs, and estuaries. Withdrawal of water for cooling purposes causes the loss of fish eggs, larvae, and juveniles through impingement or entrainment. The discharge of water causes thermal and chemical pollution, and can cause alteration of stream flow patterns and the disruption of the thermal and dissolved oxygen stratification in those water bodies.

The biological consequences of water use by power plants depend upon the species of organisms involved, the mechanical and physiological stresses on the organisms, and the ecological role of the organisms. To assess the impacts of power plants and other habitat modifications on fish populations, it is necessary to identify fish eggs, larvae, and juveniles of different species. However, up to now, descriptions of the developmental stages of fishes have been scattered throughout a large number of sources.

The *Development of Fishes of the Mid-Atlantic Bight* is a reference which compiles descriptions of the egg, larval, and juvenile stages of over 300 fish species, and includes dichotomous keys useful for identifying species. Descriptions of spawning migrations and life habits of adult fishes, their geographic range and distribution, and movements of fish at all life stages are also included.

With this kind of baseline taxonomic information, biologists will be able to assess the management implications of power plant siting and other habitat modifications on aquatic populations and provide information to decision makers. We believe these books are a major step in providing the type of information necessary to incorporate environmental considerations into resource development decisions.

Lynn A. Greenwalt

Director, U.S. Fish and Wildlife Service

The Biological Services Program was established within the U.S. Fish and Wildlife Service to supply scientific information and methodologies on key environmental issues which impact fish and wildlife resources and their supporting ecosystems. The mission of the Program is as follows:

1. To strengthen the Fish and Wildlife Service in its role as a primary source of information on national fish and wildlife resources, particularly in respect to environmental impact assessment.
2. To gather, analyze, and present information that will aid decision makers in the identification and resolution of problems associated with major land and water use changes.
3. To provide better ecological information and evaluation for Department of the Interior development programs, such as those relating to energy development.

Information developed by the Biological Services Program is intended for use in the planning and decision making process to prevent or minimize the impact of development on fish and wildlife. Biological Services research activities and technical assistance services are based on an analysis of the issues, the decision makers involved and their information needs, and an evaluation of the state of the art to identify information gaps and determine priorities. This is a strategy to assure that the products produced and disseminated will be timely and useful.

Biological Services projects have been initiated in the following areas:

- Coal extraction and conversion
- Power plants
- Geothermal, mineral, and oil shale development
- Water resource analysis, including stream alterations and western water allocation
- Coastal ecosystems and Outer Continental Shelf development
- Systems and inventory, including National Wetlands Inventory, habitat classification and analysis, and information transfer.

The Program consists of the Office of Biological Services in Washington, D.C., which is responsible for overall planning and management; National Teams which provide the Program's central scientific and technical expertise and who arrange for contracting Biological Services studies with States, universities, consulting firms, and others; regional staff who provide a link to problems at the operating level; and staff at certain Fish and Wildlife Service research facilities who conduct in-house research studies.

CONTENTS

GENERAL INTRODUCTION

As noted by Mansueti and Hardy (1967) in the first edition of Volume I of this series, the early developmental stages of most fishes are either poorly known or completely unknown. Despite the fundamental importance of this knowledge to many aspects of fishery biology and ichthyology, this situation still persists.

OBJECTIVES

The primary purpose of this series is to synthesize the world literature on fishes occurring in the Mid-Atlantic Bight of the United States. The successful accomplishment of this goal serves a number of useful functions, among which are greater ease in identifying young fishes and fish eggs, the systematization of information gaps, and the stimulation of studies in areas where such gaps have been clearly demonstrated. Although some original data have been included in this series, time constraints have kept this to a minimum, primary efforts having been directed toward a comprehensive review of existing literature.

FORMAT

The geographical area considered extends from the northern boundary of New Jersey to the southern boundary of Virginia from tidal freshwater out to the 100 fathom contour (see fig. 1).

Data have been presented on 321 species. Mansueti and Hardy (1967) arranged the species in Volume I in the sequence used by the American Fisheries Society (1960). Although disagreements exist with this arrangement as a phylogenetic sequence it is used here to order the species and families in this series so that the revised Volume I will remain intact. In some cases recent systematic revisions have demanded realignment at familial levels or the updating of generic and specific names.

The series is presented in six volumes as follows: Volume I, Acipenseridae through Ictaluridae, 50 species; Volume II, Anguillidae through Syngnathidae, 48 species; Volume III, Aphredoderidae through Rachycentridae, 52 species; Volume IV, Carangidae through Ephippidae, 52 species; Volume V, Chaetodontidae through Ophidiidae, 52 species; and Volume VI, Stromateidae through Ogcocephalidae, 67 species.

Species accounts are arranged alphabetically within family groupings. Each species account is divided into the following major divisions:

ADULTS—meristics, morphometrics and general description.

DISTRIBUTION AND ECOLOGY—range, habitat and movements of adults, larvae, and juveniles.

SPAWNING—description of season, location, conditions of spawning, and fecundity.

EGGS—description of ripe ovarian, unfertilized or fertilized eggs.

EGG DEVELOPMENT—developmental sequences, physical limiting factors and incubation times.

YOLK-SAC LARVAE—size range, morphology, development and pigmentation.

LARVAE—size range, morphology, development and pigmentation.

PREJUVENILES (not recognized in all volumes)—size range, morphology, development and pigmentation.

JUVENILES—size range, morphology, development and pigmentation.

GROWTH (not given in all volumes)—average and/or representative growth rates, especially preadult growth.

AGE AND SIZE AT MATURITY—average age and size at maturity plus variation if these data are available.

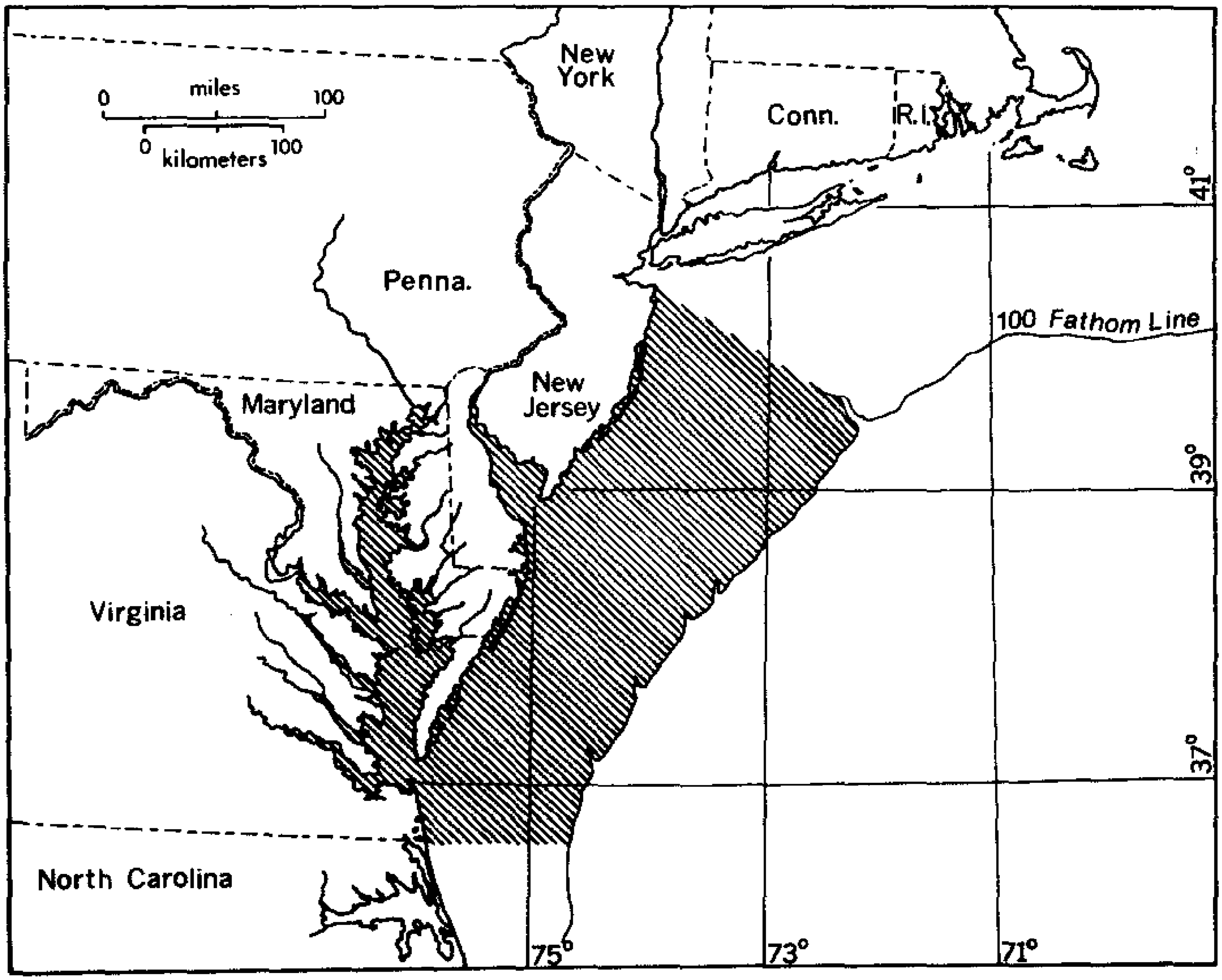

Fig. 1. Map of the Chesapeake Bay and adjacent Mid-Atlantic Bight. Hatching indicates the area considered in this series.

LITERATURE CITED—abbreviated citations to literature consulted for that account. *Complete citations in Bibliography.*

Superscript numbers in each species account refer to the abbreviated citations given at the end of each account. Complete citations may be found in the bibliography at the end of each volume. In prefaces, introductions, family accounts and figure legends, citations are given by author and date, rather than superscript. Throughout, parenthetical initials follow original unpublished information provided by the person whose initials are given (see preface for full name and address). Each volume has its own bibliography and index. No cumulative bibliography or index has been attempted.

Illustrations are of mixed quality and utility. For the most part they are simply reprinted from the literature. In some cases, however, previously published figures have been redrawn, and a number of original illustrations are included. Figure legends cite the artist or delineator. Redrawings are usually of figures which are unique in that they provide the only illustrations of particular features or stages and will not reproduce well or are confusing or inaccurate in detail. Attempts have been made to exclude drawings of misidentified specimens; however, error in judgement is possible. Where available, multiple illustrations of the same stage are included if they show geographic variation or if the authors were unable to determine which illustration provided the most accurate representation. In addition, a number of drawings which have been published in rare or generally unavailable sources have been included primarily for their historic value.

TERMINOLOGY

For the most part, terminology and methods of measuring and counting are those of Hubbs and Lagler (1958); however, these terms are specifically for adult forms and must be modified or replaced by different ones for early developmental stages.

For illustrations of typical developmental stages and larval anatomy see fig. 2.

Definitions and terms for developmental stages vary considerably depending on the investigator and the species worked on. The following terminology has been standardized:

YOLK-SAC LARVA—stage between hatching and absorption of yolk;

LARVA—stage between absorption of yolk and acquisition of minimum adult fin ray complement;

PREJUVENILE—stage between acquisition of minimum adult fin ray complement and assumption of adult body form; used only where strikingly different from juvenile (cf. Hubbs, 1958; *Tholichthys* stage of butterflyfishes, querimana stage of mullets, etc.);

JUVENILE—stage between acquisition of minimum adult fin ray complement and sexual maturity or between prejuvenile stage and adult;

ADULT—sexually mature.

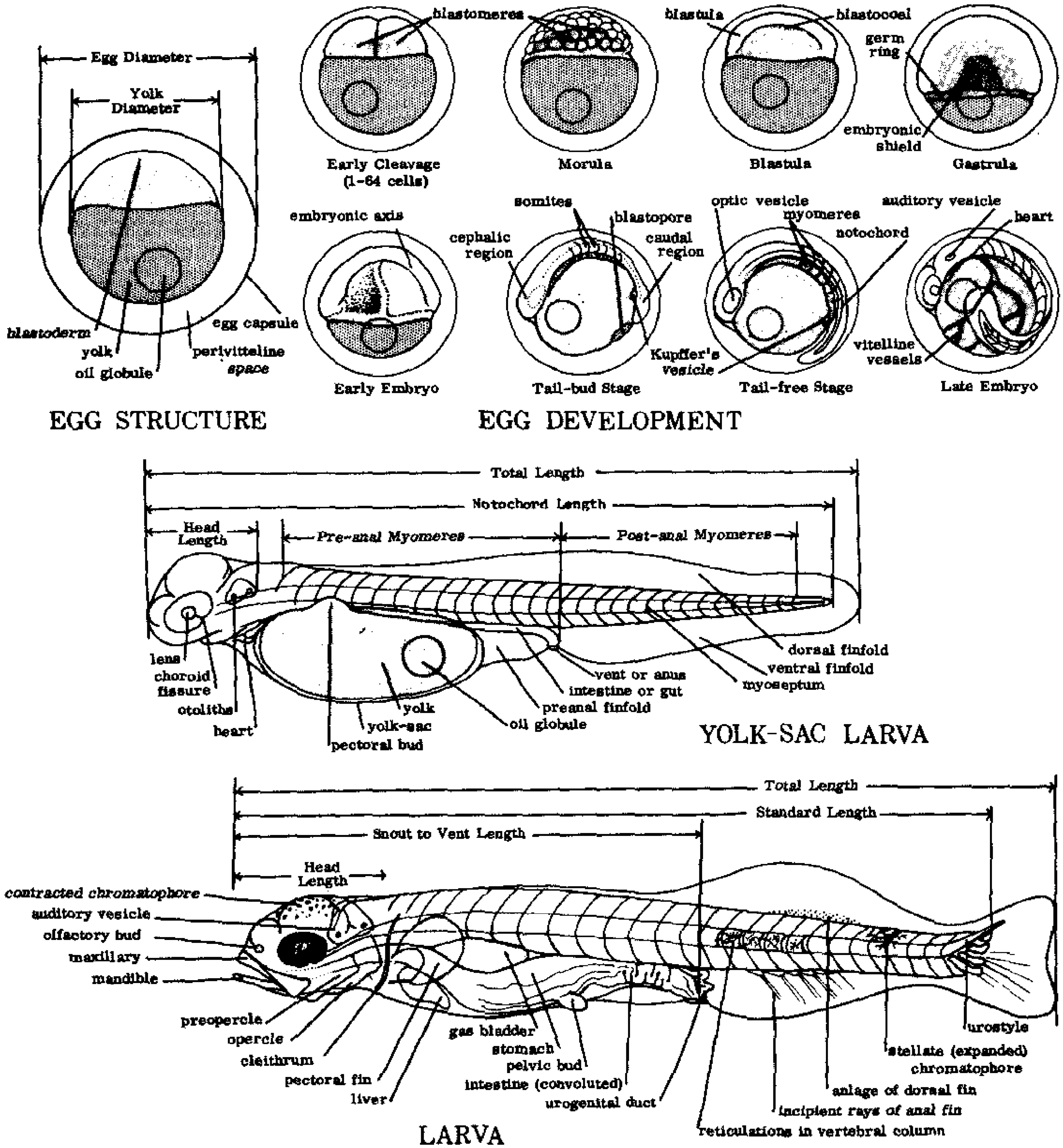

Fig. 2. Diagrammatic representation of morphology and development of egg and larval stages of a typical *teleost.*

GLOSSARY

A. Abbreviation for anal fin.

abbreviate heterocercal. Tail in which the vertebral axis is prominently flexed upward, only partly invading upper lobe of caudal fin; fin fairly symmetrical externally.

adherent. Attached or joined together, at least at one point.

adhesive egg. An egg which adheres on contact to substrate material or other eggs; adhesiveness of entire egg capsule may or may not persist after attachment.

adipose fin. A fleshy rayless median dorsal structure, located behind the true dorsal fin.

adnate. Congenitally united; conjoined.

adult. Sexually mature as indicated by production of gametes.

anadromous. Fishes which ascend rivers from the sea to spawn.

anal. Pertaining to the anus or vent.

anal fin. Unpaired median fin immediately behind anus or vent.

anal fin origin. Anteriormost point at which the anal fin attaches to the body.

anlage. Rudimentary form of an anatomical structure; primordium.

anus. External orifice of the intestine; vent.

auditory vesicle. Sensory anlage from which the ear develops; clearly visible during early development.

axillary process. Enlarged accessory scale attached to the upper or anterior base of pectoral or pelvic fins.

BL. Abbreviation for body length.

barbel. Tactile process arising from the head of various fishes.

blastocoel. Cavity of the blastula; segmentation cavity.

blastoderm. *Sensu strictu*, early embryonic tissue composed of blastomeres; more generally, embryonic tissue prior to formation of embryonic axis.

blastodisc. Embryo-forming area of egg prior to cleavage.

blastomeres. Individual cells formed during cleavage.

blastopore. Opening formed by and bordered by the germ ring as it extends over the yolk.

blastula. Stage in embryonic development which represents the final product of cleavage stages, characterized by formation of the blastocoel.

body length. A specialized method of measuring, generally applied only to billfishes, and defined by Rivas (1956a) as the distance from the tip of the mandible (with jaws closed) to the middle point on the posterior margin of the middle caudal rays.

branched ray. Soft ray with two or more branches distally.

branchial arches. Bony or cartilaginous structures, supporting the gills, filaments and rakers.

branchiostegals. Struts of bone inserting on the hyoid arch and supporting, in a fanwise fashion, the branchiostegal membrane; branchiostegal rays.

buoyant egg. An egg which floats free within the water column; pelagic.

C. Abbreviation for caudal fin.

caeca. Finger-like outpouchings at boundary of stomach and intestine.

catadromous. Fishes which go to sea from rivers to spawn.

caudal fin. Tail fin.

caudal peduncle. Area lying between posterior end of anal fin base and base of caudal fin.

cheek. Lateral surface of head between eye and opercle, usually excluding preopercle.

chorion. Outer covering of egg; egg capsule.

choroid fissure. Line of juncture of invaginating borders of optic cup; apparent in young fish as a trough-like area below lens.

chromatophores. Pigment-bearing cells; frequently capable of expansions and contractions which change their size, shape, and color.

cirrus. Generally small, dermal, flap-like or tentacle-like process on the head or body.

cleavage stages. Initial stages in embryonic development where divisions of blastomeres are clearly marked; usually include 1st through 6th cleavages (2–64 cells).

cleithrum. Prominent bone of pectoral girdle, clearly visible in many fish larvae.

ctenoid scale. Scales with comb-like margin; bearing cteni.

cycloid scale. Scales with evenly curved free border, without cteni.

D. Abbreviation for dorsal fin.

demersal egg. An egg which remains on the bottom, either free or attached to substrate.

dorsal fins. Median, longitudinal, vertical fins located on the back.

dorsal fin origin. Point where first dorsal ray or spine attaches to body.

early embryo. Stage in embryonic development characterized by formation of embryonic axis.

egg capsule. Outermost encapsulating structure of the egg, consisting of one or more membranes; the protective shell.

egg diameter. In nearly spherical eggs, greatest diameter; in elliptical eggs given as two measurements, the greatest diameter or major axis and the least diameter or minor axis.

emarginate. Notched but not definitely forked, as in the shallowly notched caudal fin of some fishes.

embryonic axis. Primitive differentiation of the embryo; an elongate thickening of blastodermal tissue.

embryonic shield. Thickened shield-like area of the blastoderm at caudal edge of the germ ring.

erythrophores. Red or orange chromatophores.

esophagus. Alimentary tract between pharynx and stomach.

falcate. Deeply concave as a fin with middle rays much shorter than anterior and posterior rays.

finfold. Median fold of integument which extends along body of developing fishes and from which median fins arise.

FL. Abbreviation for fork length.

fork length. Distance measured from the anteriormost point of the head to the end of the central caudal rays.

ganoid scales. Diamond- or rhombic-shaped scales consisting of bone covered with enamel.

gas bladder. Membranous, gas-filled organ located between the kidneys and alimentary canal in teleosts; air bladder or swim bladder.

gastrula. Stage in embryonic development between blastula and embryonic axis.

germ ring. The thickened rim of the blastoderm evident during late blastula and gastrula stages.

germinal disc. The blastodisc.

gill arches. See branchial arches.

gill rakers. Variously-shaped bony projections on anterior edge of the gill arches.

granular yolk. Yolk consisting of discrete units of finely to coarsely granular material.

guanophores. White chromatophores; characterized by presence of iridescent crystals of guanine.

gular fold. Transverse membrane across throat.

gular plate. Ventral bony plate between anterior third of lower jaws, as in *Amia calva.*

heterocercal. Tail in which the vertebral axis is flexed upward and extends nearly to tip of upper lobe of caudal fin; fin typically asymmetrical externally, upper lobe much longer than lower.

HL. Abbreviation for head length.

head length. Distance from anteriormost tip of head to posteriormost part of opercular membrane, excluding spine; prior to development of operculum, measured to posterior end of auditory vesicle.

holoblastic. Type of cleavage in which the entire egg, including the yolk, undergoes division.

homocercal. Tail in which the vertebral axis terminates in a penultimate vertebra followed by a urostyle (the fusion product of several vertebral elements); fin perfectly symmetrical externally.

hypochord. A transitional rod of cells which develops under the notochord in the trunk region of some embryos.

hypurals. Expanded, fused, haemal spines of last few vertebrae which support caudal fin.

incubation period. Time from fertilization of egg to hatching.

interorbital. Space between eyes over top of head.

iridocytes. Crystals of guanine having reflective and iridescent qualities.

isocercal. Tail in which vertebral axis terminates in median line of fin, as in Gadiformes.

isthmus. The narrow area of flesh in the jugular region between gill openings.

jugular. Pertaining to the throat.

juvenile. Young fish after attainment of minimum adult fin ray counts and before sexual maturation.

keeled. With a ridge or ridges.

Kupffer's vesicle. A small, vesicular, ventro-caudal pocketing which forms as blastopore narrows.

larva. Young fish between time of hatching and attainment of minimum adult fin ray counts.

late embryo. Stage prior to hatching in which the embryo has developed external characteristics of its hatching stage.

lateral line. Series of sensory pores and/or tubes extending backward from head along sides.

lateral line scales. Pored or notched scales associated with the lateral line.

mandible. Lower jaw, comprised of three bones: dentary, angular and articular.

maxillary. The dorsalmost of the two bones in the upper jaw.

Meckel's cartilage. Embryonic cartilaginous axis of the lower jaw in bony fishes.

melanophores. Black chromatophores.

mental. Pertaining to the chin.

meroblastic. Type of cleavage in which only the blastodisc undergoes division.

micropyle. Opening in egg capsule through which spermatozoa enter.

morula. Stage in development of egg in which blastomeres form a mulberry-like cluster.

myomeres. Serial muscle bundles of the body.

myoseptum. Connective tissue partitions separating myomeres.

nape. Area immediately posterior to occipital region.

nasal. Pertaining to region of the nostrils, or to the specific bone in that region.

NL. Abbreviation of notochord length.

notochord. Longitudinal supporting axis of body which is eventually replaced by the vertebral column in teleostean fishes.

notochord length. Straight-line distance from anteriormost part of head to posterior tip of notochord; used prior to and during notochord flexion.

occipital region. Area on dorsal surface of head, beginning above or immediately behind eyes and extending backwards to end of head.

oil globule(s). Discrete sphere(s) of fatty material within the yolk.

olfactory buds. Incipient olfactory organs.

optic vesicles. Embryonic vesicular structures which give rise to the eyes.

otoliths. Small, calcareous, secreted bodies within the inner ear.

P. Abbreviation for pectoral fin.

palatine teeth. Teeth on the paired palatine bones in the roof of the mouth of some fishes.

pectoral bud. Swelling at site of future pectoral fin; anlage of pectoral fin.

pectoral fins. Paired fins behind head, articulating with pectoral girdle.

pelagic. Floating free in water column; not necessarily near the surface.

pelvic bud. Swelling at site of future pelvic (ventral) fins; anlage of pelvic fin.

pelvic fins. Paired fins articulating with pelvic girdle; ventral fins.

periblast. A layer of tissue between the yolk and cells of blastoderm which is observed as a thin border around blastula.

peritoneum. Membranous lining of abdominal cavity.

perivitelline space. Fluid-filled space between egg proper and egg capsule.

pharyngeal teeth. Teeth on the pharyngeal bones of the branchial skeleton.

postanal myomeres. The number of myomeres between posterior margin of anus and the most posterior myoseptums.

preanal length. Method of measuring often not stated, assumed to be about equivalent to snout to vent length in larvae.

preanal myomeres. The number of myomeres between the anteriormost myoseptum and the posterior margin of anus.

predorsal scales. Scales along dorsal ridge from occiput to origin of dorsal fin.

prejuvenile. Developmental stage immediately following acquisition of minimum fin ray complement of adult and before assumption of adult-like body form; used only where strikingly different from juvenile (*cf.* Hubbs, 1958; *Tholichthys* stage of butterflyfishes, querimana stage of mullets, etc.).

premaxillary. The ventralmost of the two bones included in the upper jaw.

primordium. Rudimentary form of an anatomical structure; anlage.

principal caudal rays. Caudal rays inserting on hypural elements; the number of principal rays is generally defined as the number of branched rays plus two.

procurrent caudal rays. A series of much shorter rays anterior to the principal caudal rays, dorsally and ventrally, not typically included in the margin of the caudal fin.

pronephric ducts. Ducts of pronephric kidney of early developmental stages.

scute. A modified, thickened scale, often spiny or keeled.

sigmoid heart. The S-shaped heart which develops from the primitive heart tube.

SL. Abbreviation for standard length.

snout to vent length. Distance from anteriormost part of head to posterior margin of anus; the precise method of measurement often not stated.

soft rays. Bilaterally paired, usually segmented, fin supports.

somites. Primitive, segmented, mesodermal tissue along each side of notochord.

spines. Unpaired, unsegmented, unbranched fin supports, usually (but not always) stiff and pungent.

standard length. In larvae, straight-line distance from anteriormost part of head to end of hypural elements; not applicable to larvae prior to notochord flexion. (In juveniles and adults measured from most anterior point of snout or upper lip.)

stomodeum. Primitive invagination of the ectoderm which eventually gives rise to the mouth.

tail-bud stage. Stage of embryonic development characterized by a prominent caudal bulge and marked development of cephalic region.

tail-free stage. Stage of embryonic development characterized by separation of the tail from the yolk.

TL. Abbreviation for total length.

total length. Straight-line distance from anteriormost part of head to tip of tail; all older literature references not stated differently are assumed to be total length.

urostyle. Terminal vertebral element in higher teleosts, derived from the fusion and loss of several of the most posterior centra of the more primitive forms.

V. Abbreviation for the central or pelvic fin.

vent. Anus.

ventral fins. Paired fins articulating with the pelvic girdle; pelvic fins.

vitelline vessels. Arteries and veins of yolk region.

water-hardening. Expansion and toughening of egg capsule due to absorption of water into the perivitelline space.

width of perivitelline space. Distance between yolk and egg capsule expressed either as direct measurement or a ratio of the egg diameter.

xanthophores. Yellow chromatophores.

yolk. Food reserve of embryonic and early larval stages, usually seen as a yellowish sphere diminishing in size as development proceeds.

yolk diameter. Greatest diameter of yolk; more accurately measurable prior to embryo formation.

yolk plug. Yolk within the blastopore.

yolk sac. A bag-like ventral extension of the primitive gut containing the yolk.

yolk-sac larva. A larval fish characterized by the presence of a yolk-sac.

VOLUME III DEDICATION

For all of my friends at Chesapeake Biological Laboratory, Solomons, Maryland, in recognition of their support during the years that I was privileged to work on this project.

INTRODUCTION TO VOLUME III

This volume contains accounts of the life history and development of fifty-three species of teleostean fishes occurring in the Mid-Atlantic Bight (Aphredoderidae through Rachycentridae). Although this work is primarily a compilation of previously published information, certain individuals have generously permitted use of their unpublished illustrations and data. Original illustrations are included for the following species:

Aphredoderus sayanus eggs and larvae	Elizabeth Ray Peters
Centropristis striata larvae and juveniles	Alice J. Lippson Nancy S. Smith
Mycteroperca microlepis juvenile	Alice J. Lippson
Morone saxatilis larva	Alice J. Lippson
Enneacanthus gloriosus larva	Alice J. Lippson
Etheostoma olmstedi eggs, larvae	Deborah C. Kennedy Jerry D. Hardy, Jr.
Rachycentron canadum juvenile	Elizabeth Ray Peters Daniel M. Carver

Original text contributions are indicated by initials as following:

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I wish to thank the following individuals for reviewing the various manuscripts: Charles E. Dawson, Gulf Coast Research Laboratory, Ocean Springs, Mississippi, for reviewing Rachycentridae; Ronald A. Fritzsche, University of Mississippi, Oxford, Mississippi, for reviewing Priacanthidae; Edward D. Houde, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, Florida, for reviewing Percidae (*Perca, Stizostedion*); G. David Johnson, Division of Fishes, United States National Museum, for reviewing Caproidae, Serranidae, Lutjanidae, and Pomatomidae; Arthur W. Kendall, Jr., National Marine Fisheries Service, Northeast Fisheries Center, Sandy Hook, New Jersey, for reviewing Serranidae; F. Douglas Martin, Chesapeake Biological Laboratory, Solomons, Maryland, for reviewing Aphredoderidae and Lobotidae; Eileen M. Setzler, Chesapeake Biological Laboratory, Solomons, Maryland, for reviewing

Percichthyidae; Robert G. Werner, College of Environmental Science and Forestry, State University of New York, Syracuse, New York, for reviewing Centrarchidae; and Howard E. Winn, University of Rhode Island, Kingston, Rhode Island, for reviewing Percidae (*Etheostoma*, *Percina*).

Work on this volume prior to 1975 was supported entirely by funds from the Chesapeake Biological Laboratory. I am extremely grateful to Dr. L. Eugene Cronin for making that support possible. The Sport Fishing Institute funded one of our summer aides, Miss Vina Issacs, whose principal task was reviewing and editing the manuscripts then available.

I am especially grateful to our artist, Elizabeth Ray Peters, for her outstanding work on this project. Her original drawings of fish eggs and larvae are among the best that I have seen. I thank, also, Joan Ellis, Tamiko Karr, and Donna Davis, students from St. Mary's College, for the numerous delineations which they did as volunteer interns.

This project would probably not have been possible without the assistance given us by Jack Marquardt, librarian, U.S. National Museum; Leonard Bikowski and Hazel Dawson, of the Library of the U.S. Department of the Interior; and Caroline Essex, librarian, Chesapeake Biological Laboratory. I will long remember the patience of these people in dealing with our numerous and often urgent calls for help.

George Drewry, research coordinator, kept the complex machinery of the project running smoothly, and, in its final stages, checked and standardized the bibliographies of this and two other volumes of the series. Julia Clark maintained and organized the reprint library—a task which became especially difficult as the momentum of the project increased. Judy Wiley, Ruth Wilson, and Herbert Harris assisted with the editing of the final manuscript, and Hillary Handwerger made a final check on the bibliographies of all six volumes of the series. The entire manuscript was reviewed and edited by Douglas Martin.

Vina Issacs and Walter Boynton, both former summer students at Chesapeake Biological Laboratory, assisted with library research and editing during the early stages of the development of the project. Daniel M. Carver, a more recent summer student, assisted with the literature search, and also prepared a number of illustrations used in this volume.

The patience exhibited by Cynthia Simmonds and Eunice (Sam) Benson in typing and re-typing the numerous manuscripts in this and the other five volumes of the series is almost beyond comprehension. I will always remember and appreciate their help. At times it became necessary to call in additional typists. These included: Marjorie Blackwell, Joyce Stinson, Diane Haft, Clovia Hutchins, and Steven Drewry. Without their excellent work we would have probably met even fewer deadlines than we actually managed to meet.

Eurath Hardy, August Selckmann, Jr., and Ronald Bishop spent hundreds of hours in the darkroom when the rest of us were simply too busy to do so. A high percentage of the figures presented in this volume are the results of their volunteer efforts.

I wish, finally, to thank an innocuous little black dog named Muttsy, whose maturity and sense of humor kept the entire "Fish Atlas" crew from going insane during the final frantic weeks of the preparation of all these volumes.

Aphredoderus sayanus

pirate perches
Aphredoderidae

FAMILY APHREDODERIDAE

Aphredoderus sayanus, the only living member of the family Aphredoderidae, is limited in distribution to lowland areas of the central, southern, and eastern United States. It occurs primarily in muck-bottomed freshwater ponds, lakes, swamps, and streams, but occasionally enters brackish water, and has been recorded at a maximum salinity of 10.15 ppt.

In *Aphredoderus* the anus is jugular. The single dorsal fin has two or three weak spines. The opercle is equipped with a sharp spine. The edge of the preopercle is strongly serrate. The lateral line is absent or incomplete.

Some authors have reported guardianship of the eggs by both parents (buccal incubation may also occur, but has not been confirmed). The eggs are small and possess a single large oil globule.

Yolk-sac larvae are initially unpigmented, but later develop a distinct row of melanophores under the posterior half of the tail. The oil globule is anterior, and the anus is approximately two-fifths the distance to the tail tip. Larvae are characterized by the single dorsal fin, the position of the anal origin under the posterior one-half to one-fourth of the dorsal fin, a very short preanal finfold, and, in most specimens, a definite bar of pigment behind the eye. Pigmentation may vary geographically. In illustrations of specimens from the Mid-Atlantic Bight, melanophores are developed primarily on the head. In a single illustration of a small specimen from Tennessee, melanophores are well-developed over the entire body. At about 9.0 mm (or at about the time of appearance of the pelvic fins) the anus begins to migrate anteriorly from its position just in front of the anal fin. This migration is complete during the juvenile stage and involves formation of a major intestinal flexure, and passage of the intestine through a foramen in the pelvic girdle and the musculature of the abdominal wall.

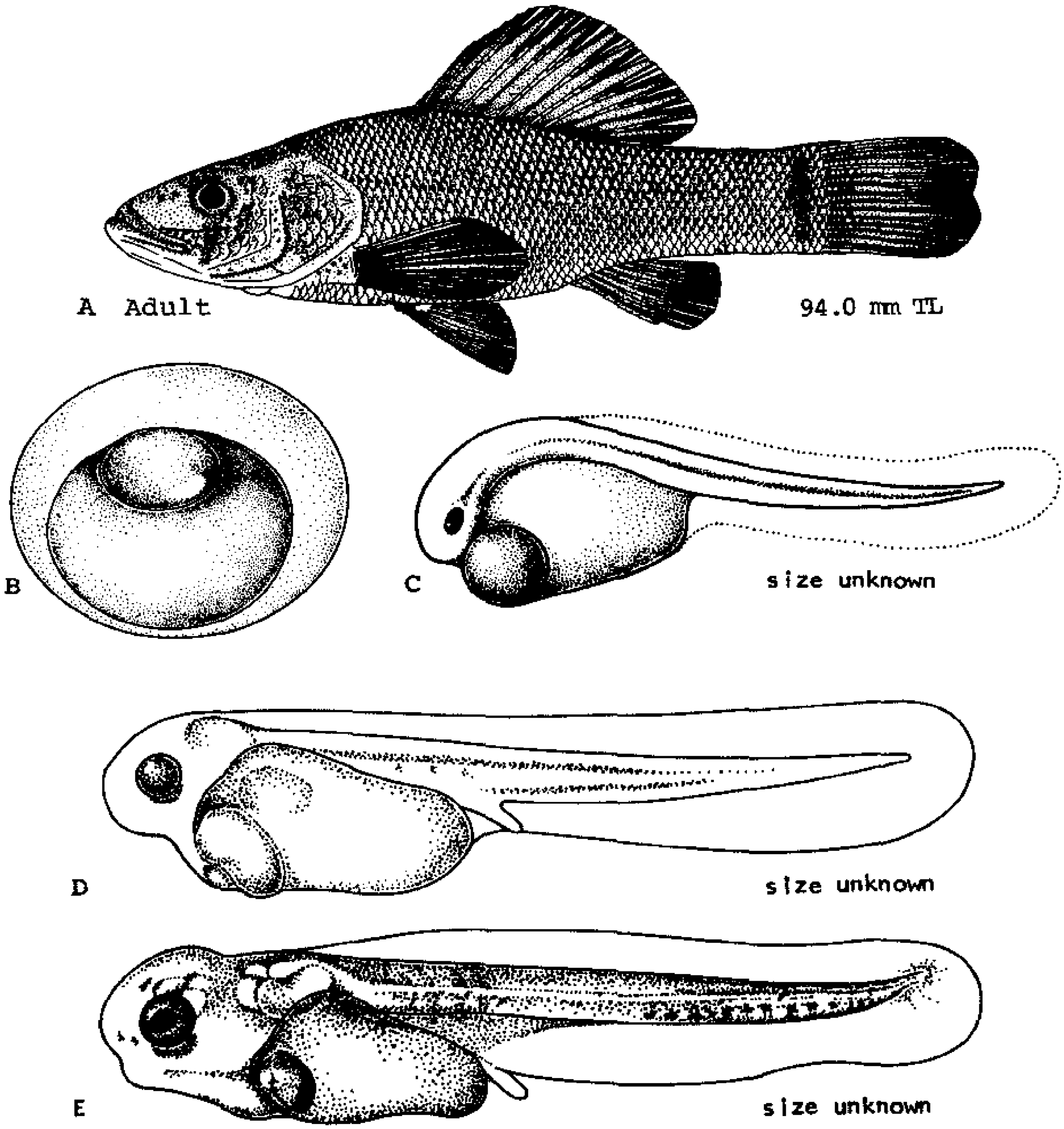


Fig. 3. *Aphredoderus sayanus,* Pirate perch. A. Adult, 94.0 mm TL. B. Egg, 31 hours after fertilization. C. Yolk-sac larva, newly hatched, 4 days after fertilization. D. Yolk-sac larva, 6 days after fertilization. E. Yolk-sac larva, 7 days after fertilization, flexion evident in notochord (projection of intestine may be inaccurate). *(A, Trautman, M. B., 1957: fig. 122. B-E, Drawn from photographs, Elizabeth Ray Peters, delineator.)*

Aphredoderus sayanus (Gilliams), Pirate perch

ADULTS

D. III to IV, 9–13; A. II to III, 5–8 [8,10] (although 8 may not be an adult count [16]); P. 10 [30]–14; [8,10] V. I, 7; [17,19,24] scales in lateral series 44 [17,20]–60, longitudinal scale rows, 8–11; [30] vertebrae 13 + 16; [20] branchiostegals 6.[30]

Proportions as times in TL: Head 3,[17] depth 3.1–3.5. Eye diameter 4.5–5.3 times in head.[25] At ca. 80 mm, first anal spine one-third length of second, second spine one-fourth length of third.[16]

Body more or less cylindrical, blunt forward, somewhat compressed behind; caudal peduncle stout; [15,19,25] head large, cheeks scaled; [20] lower jaw somewhat larger than upper; [14] mouth large, oblique; [35] maxilla to front eye; [15] premaxillary not protractile; [13] gill rakers short; [35] jaws, vomer, palatines, and pterygoids covered with fine rows of teeth.[20] Lateral line incomplete or absent [15,20] (poorly developed in Midwest, better developed along Atlantic coast [9]). Caudal fin rounded; [20] anal fin covered with fleshy, heavily pigmented integument, spines hidden; [16] anus far in advance of anal fin.[13]

Pigmentation: Dark olive to dark brown above, sometimes olivaceous over transparent pinkish to lavender; sides lighter. Head and body profusely sprinkled with dark spots and blotches which may sometimes be arranged in longitudinal rows. White, whitish yellow, or yellowish brown below. One or two dark bars at base of caudal fin. Fins generally opaque gray-green, but variable. All fins, except pelvics, somewhat darker at bases; dorsal and caudal slaty olive, remaining fins lighter and more yellow; median fins with narrow ring of white. Both males and females iridescent during breeding season, predominate lusters violet and purple, also sometimes light copper, green, or silver; breeding adults sometimes black or nearly so.[9,13,15,17,20,24,25]

Maximum length: 130 mm.[20]

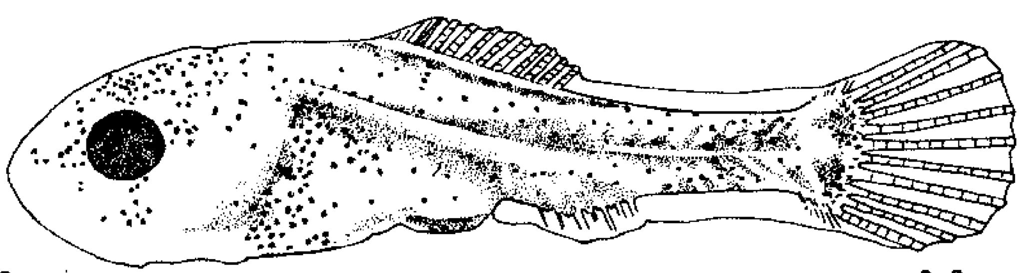
DISTRIBUTION AND ECOLOGY

Range: New York to Florida and west to Texas; north in Mississippi Valley to Great Lakes.[10,12]

Area distribution: Coastal areas of New Jersey,[3,11] Maryland,[27,29] and Virginia; [37] specifically recorded from tidal or brackish water in lower Delaware River [33] and Turner's Creek, Maryland.[30]

Habitat and movements: Adults—in clear, dark, or muddy water,[2] in streams [7,10,14,15,18] (sometimes, specifically, among tree roots along overhanging banks [32]), creeks,[10] oxbows,[24] muddy sloughs,[36] and in shoreline areas of rivers; [10] usually in areas with little or no current,[25] but also recorded from riffles choked with emergent vegetation, also in overflow ponds,[24] roadside pools and ditches,[6,10] pools left from draining rice canals (where associated with marine species),[28] sheltered ponds,[15] natural lakes,[8,10] along shoreline of large artificial lakes,[6] large springs (including calcareous springs),[10,24] swamps,[6] marshes,[24] bayous,[31] and estuaries.[24] Sometimes in stagnant water.[2] Over variable bottoms, sometimes strictly associated with dense vegetation; [22] otherwise recorded over mud,[10,25] shifting sand,[22] hard white sand,[10] soft muck (sometimes with decomposing organic matter and littered with twigs, roots, etc.), clay, gravel, and rock (including bedrock).[2,22,24] A nocturnal species,[5] resting by day, and sometimes assuming an almost vertical head down position among vegetation.[10] Form schools during spring, scatter throughout summer. Winter half-buried in sand, avoid clay or mud.[4] Maximum salinity, 10.15 ppt.[21]

Larvae—young guarded by one or both parents until about 9.0 mm long; swim in loose schools during this period.[1,4,9,14,31]



A

8.0 mm TL

Fig. 4. *Aphredoderus sayanus*, Pirate perch. A. Larva, 8.0 mm TL. (*A, Hogue, J. J., Jr.*, et al., *1976: 45.*)

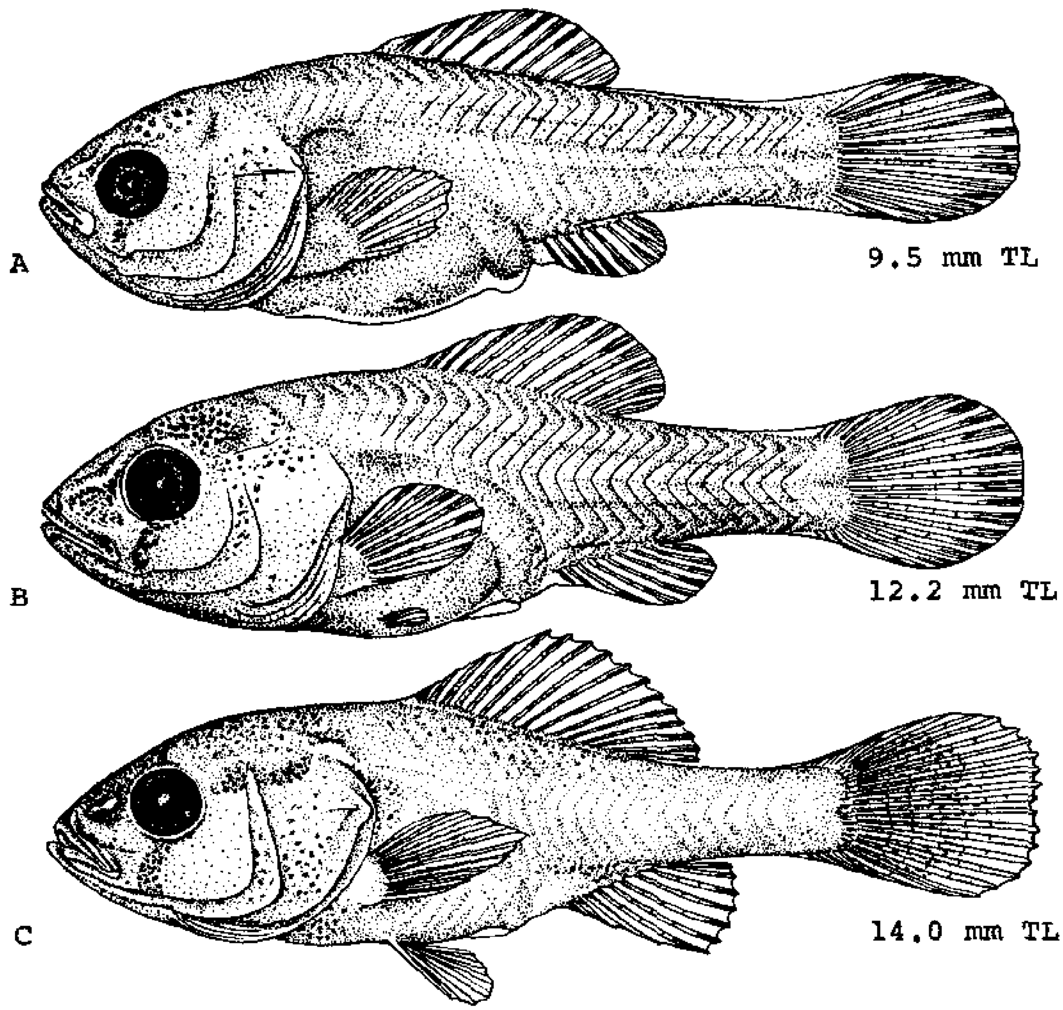


Fig. 5. *Aphredoderus sayanus*, Pirate perch. A. Larva, 9.5 mm TL. B. Larva, 12.2 mm TL. C. Juvenile, 14.0 mm TL. (*A-C, Mansueti, A. J., 1963: fig. 4.*)

Juveniles—no information.

SPAWNING

Location: Eggs recorded in abandoned sunfish nests and deserted muskrat burrows.[1]

Season: October to December in Florida; [10] artificial fertilization in Texas in late February; [34] possibly in March in vicinity of Philadelphia; [4] spawning observed in hatchery troughs in Illinois on May 1, running ripe males in nature on May 23.[25]

Temperature: Unknown.

Fecundity: 129–160.[10]

EGGS

Location: Deposited in nests and guarded by parents.[1,9,14] Some evidence suggests buccal incubation.[34]

Ripe ovarian eggs: Diameter 0.5–0.75 mm.[10]

Fertilized eggs: White, clear; diameter 1.0 mm; oil globule single, diameter 0.4 mm.[34]

EGG DEVELOPMENT

At 19–20 C:

2 hours, 15 minutes	first cleavage.

4 hours, 30 minutes	mostly 4-cell, some 8-cell stages.
9 hours	blastula formed.
17 hours, 45 minutes	late blastula.
27 hours, 15 minutes	neural tube formed.
31 hours, 20 minutes	4–8 somites.
49 hours, 15 minutes	prosencephalon and optic vesicles formed, somites visible along two-thirds length of neural tube.
64 hours, 15 minutes	somites in anterior part of body larger than those in posterior half, heart-beat and irregular body movements established.
120 hours (5 days)	one-half of embryos tail free, optic cup closed, choroid fissure evident, heart and major blood vessels displaced to left.
6–7 days	hatching.

Incubation period, at 19–20 C, 5–7 days.[34]

YOLK-SAC LARVAE

Hatching length, unknown.[23]

Myomeres 12–15 + 13–16.[23]

At approximate time of hatching, gill clefts visible, heart begins to move perpendicular to long axis of body. At 8 days after fertilization, yolk noticeably diminished, gas bladder evident. Finfold still continuous 9 days after fertilization; caudal rays visible by 10th day; [34] notochord flexed 7 days after fertilization or 0 to 1 day after hatching (FDM).

Pigmentation: At approximate time of hatching, first traces of pigment in optic cup. Several days after fertilization minute melanophores scattered over dorsum,[34] and a series of larger melanophores along ventral edge of caudal myomeres (FDM).

LARVAE

Size range described, 8.0 [23]–12.2 mm TL.

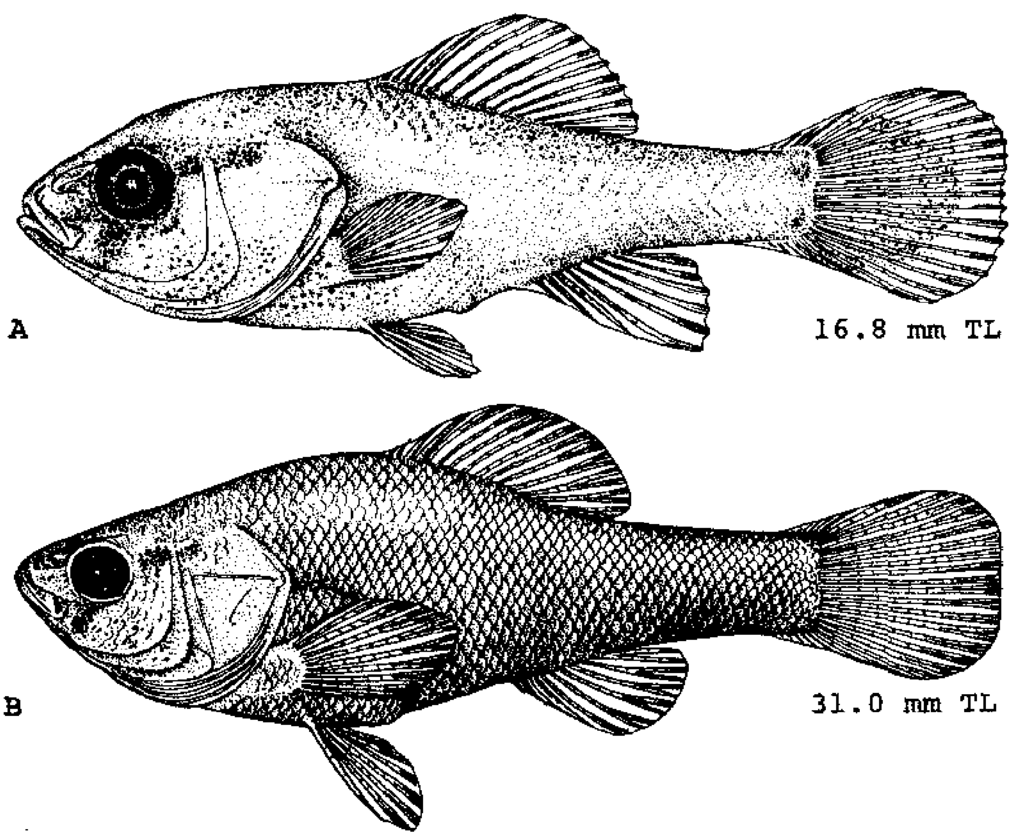


Fig. 6. *Aphredoderus sayanus*, Pirate perch. A. Juvenile, 16.8 mm TL. B. Juvenile, 31.0 mm TL. (*A, B, Mansueti, A. J., 1963: fig. 4.*)

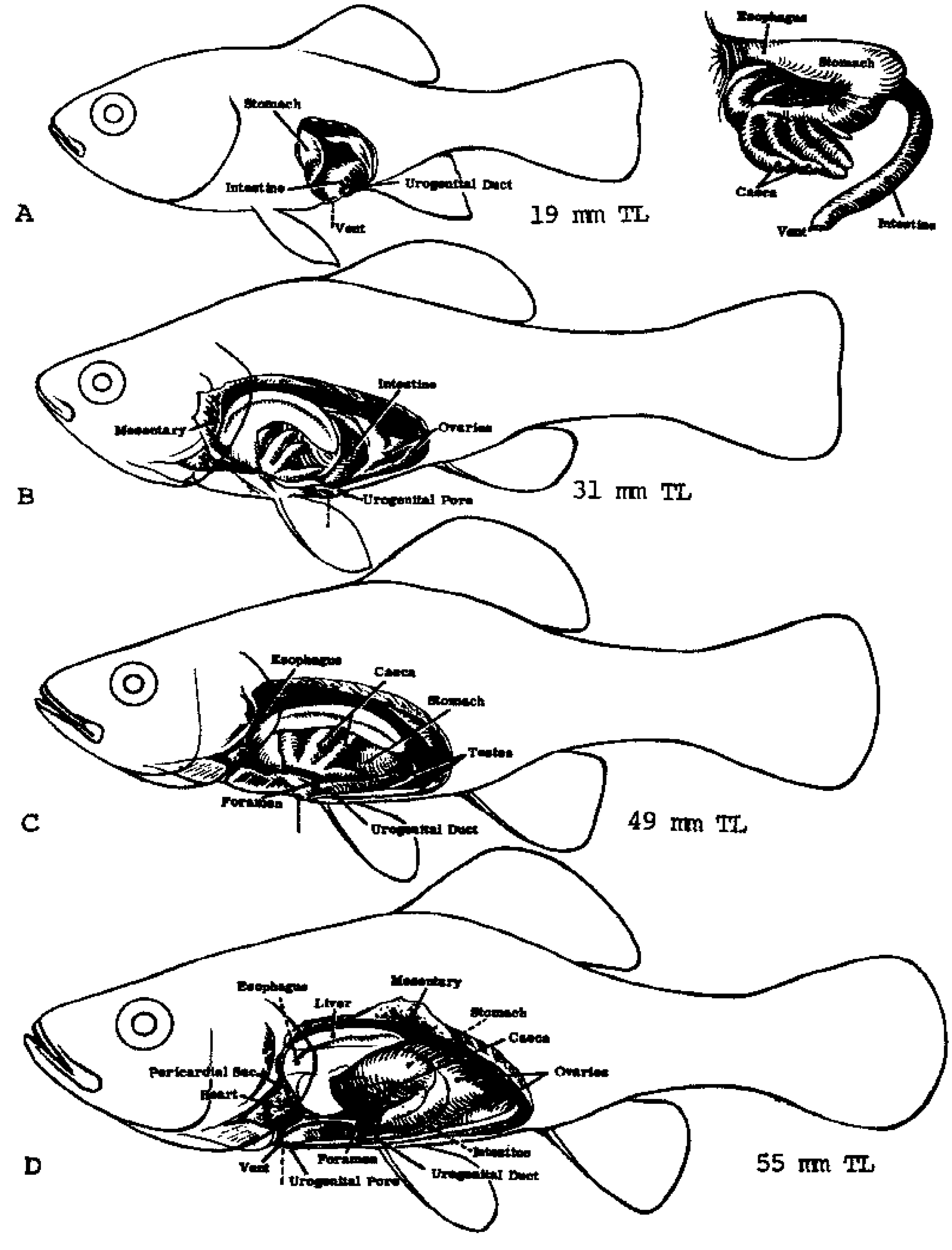


Fig. 7. *Aphredoderus sayanus*, Pirate perch. Forward migration of the anus with respect to increasing length. A. 19 mm TL. B. 31 mm TL. C. 49 mm TL. D. 55 mm TL. *(A-D, Mansueti, A. J., 1963: fig. 5.)*

At 8.0 mm TL incipient rays in dorsal and anal fins. All median fin rays formed at 13 mm TL. Pelvic buds evident at 9.0 mm TL; pelvics with developing rays at 13 mm TL.

Gas bladder evident between 2nd and 6th preanal myomere at 8.0 mm.[23] At 9.5 mm, anus immediately anterior to anal fin.[16]

Pigmentation: Variable with geographic location (JDH). In specimens from Maryland a definite bar of pigment below eye throughout stage. At 9.4 mm, few melano-

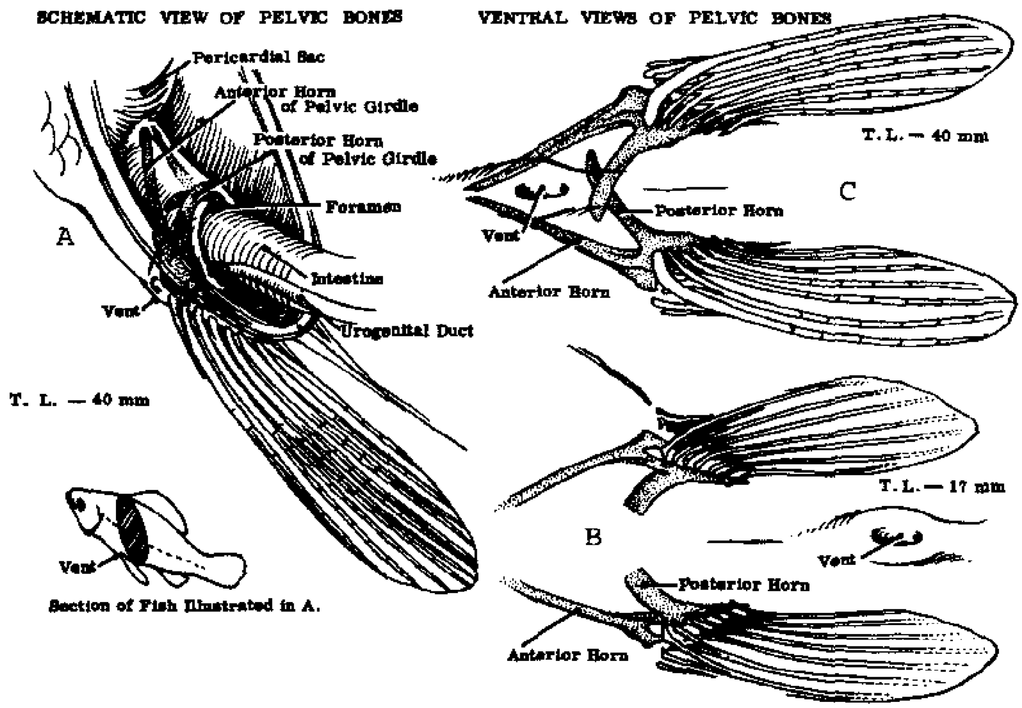


Fig. 8. *Aphredoderus sayanus,* Pirate perch. A. Pelvic bones in relation to intestine and vent in a 40 mm fish. B. Incomplete ossification of pelvic bones at 17 mm. C. Complete development of pelvic girdle at 40 mm, ventral view. *(A-C, Mansueti, A. J., 1963: fig. 6.)*

phores on head, opercle, and in membrane of caudal fin. By end of stage pigment more intense and additional pigment in region of pectoral fin, along dorsal rays, and forming a crescent band of large melanophores in caudal fin.[16] In specimens from Tennessee large stellate melanophores over entire body, most abundant on dorsal margin of head, lateral margin of gut, and along mid-lateral line. At 8.0 mm a group of melanophores developed below eye by end of stage a definite subocular bar.[23]

JUVENILES

Minimum length described: 14.0 mm TL.

At 17.0 mm preopercle with few spines. Preanal finfold evident to at least 14.0 mm. At 14.0 mm a unique keel-like structure on third anal spine; first anal ray transformed to third anal spine at 11.0–15.0 mm; at about 30 mm first anal spine 1/2 length of second, second 1/2 length of third; up to 35 mm anal fin covered with thin, transparent skin, spines visible; a unique keel-like structure on first anal ray at 35.0–40.0 mm. At 17.0 mm, pelvic girdle not ossified, intestine straight in body cavity. At 19.0 mm, intestine curved back on self, immature gonads just posterior to intestine, urogenital duct slightly behind and to left of intestine.[16] In specimens larger than 28.0 mm, anal opening between or anterior to pelvic fins.[24] Ossification of pelvic girdle complete, intestine through foramen at 45 mm.[16]

Pigmentation: Young (less than 25.0 mm) very black with few pale yellowish dots; tail margined with black.[1]

AGE AND SIZE AT MATURITY

Age at maturity, unknown. Size at maturity, females 35.0 mm (in Florida)[10] to 55.0 mm (in Chesapeake Bay region).[16]

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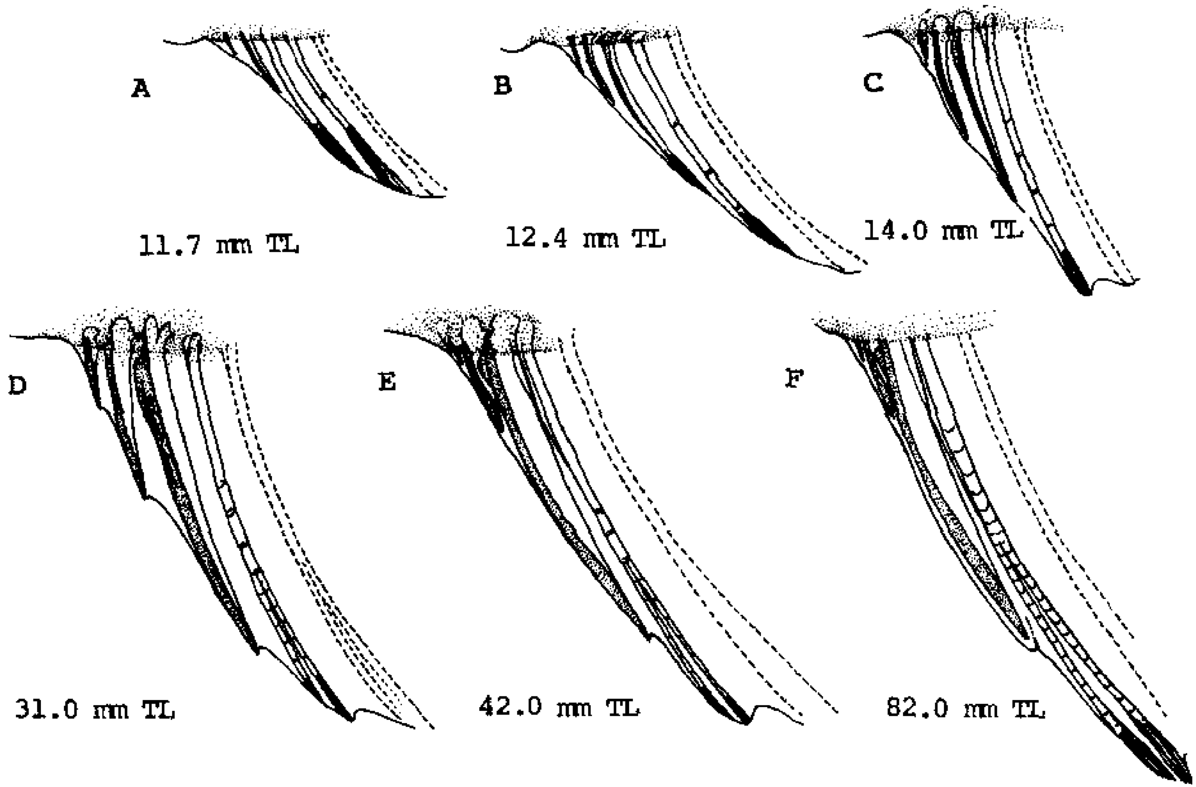

Fig. 9. *Aphredoderus sayanus*, Pirate perch. Transition of third soft anal ray into a spine. A. 11.7 mm TL. B. 12.4 mm TL. C. 14.0 mm TL. D. 31.0 mm TL. E. 42.0 mm TL. F. 82.0 mm TL. *(A-F, Mansueti, A. J., 1963: fig. 1.)*

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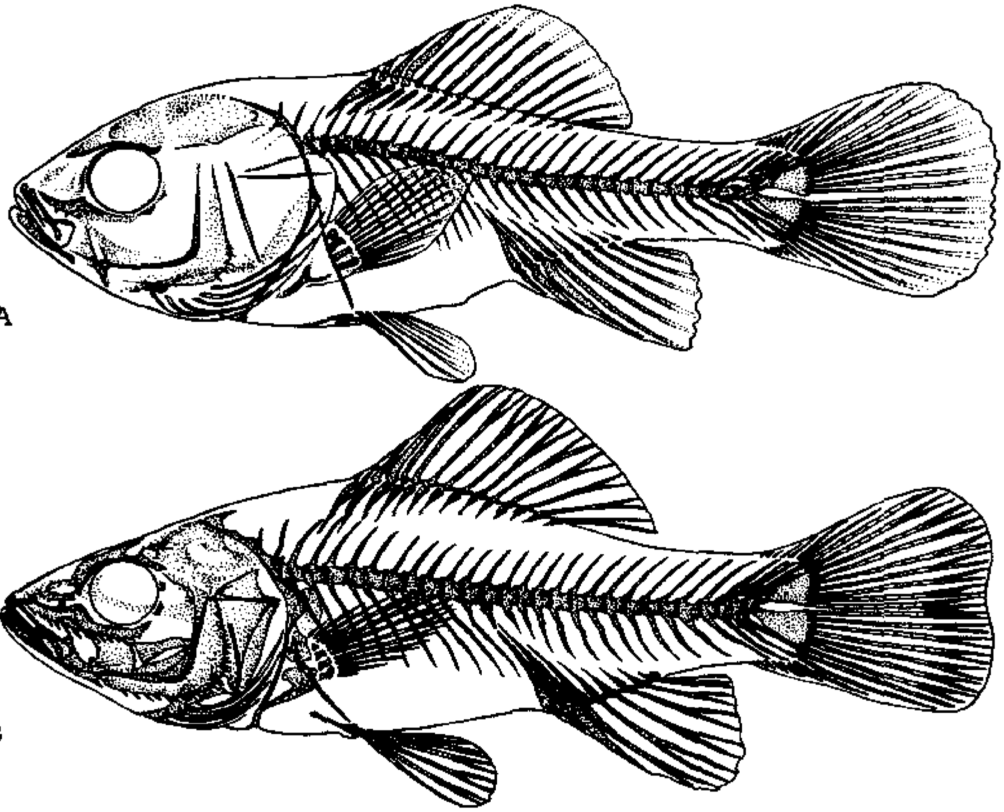


A

B

Fig. 10. *Aphredoderus sayanus,* Pirate perch. Skeletons of juvenile and young adult to show differences in ossification and position of anus. A. 17 mm TL. B. 45 mm TL. (*A, B, Mansueti, A. J., 1963: fig. 7.*)

Antigonia capros

boarfishes
Caproidae

FAMILY CAPROIDAE

Members of this family, which contains two genera and six species, occur in relatively deep waters (70–600 meters) of the Atlantic and western Pacific oceans.

Typically, these bright red fishes have rhomboid or diamond-shaped bodies, rounded caudal fins, and small ctenoid scales. Members of the subfamily Antigoniinae, of which the regional caproidid, *Antigonia capros,* is a member, have extremely deep, slender bodies, anal spines distinctly separate from the anal soft rays or connected to them by a shallow notch, and 21–23 vertebrae.

Nothing is known of the eggs of *Antigonia capros*. Larvae of this species have large heads and strikingly well-developed preopercular and cranial spines. Pigmentation initially develops over the abdominal cavity, and the anus opens at a point slightly beyond the midpoint of the total length.

Antigonia capros Lowe, Deepbody boarfish

ADULTS

D. VII (rarely VII or IX), 31 [4]–38; [6] A. III,[7] 29–34; [4] C. 4+6+6+3; [4,16] P. I, 13 (rarely 12 or 14); V. I, 5; scales 46 [4]–ca. 58; [12] gill rakers 5–6+13–16; branchiostegals 6; [4] vertebrae 10+12.[16]

Proportions as percent SL (apparently including some juveniles, JDH): Depth 136.0–98.3, snout to first dorsal spine 77.2–59.6, snout to pectoral origin 46.1–36.2, snout to pelvic origin 86.0–67.8, snout to first anal spine 92.7–76.4, head length 42.3–33.9, eye 20.2–13.9.[4]

Body compressed, elevated; head with concavities between snout and upper end of supraoccipital crest and between upper end of supraoccipital and dorsal origin; [4] mouth very small; [1] cleft of mouth angular; lower jaw slightly projecting. Teeth small, conical, in narrow band in front of and partially around side of each jaw; no teeth on vomer, palatines, or tongue.[4] Scales extended onto dorsal, anal,[5] and caudal fin bases.[4] Lateral line curving upward to below about 4th dorsal spine, then curving downward to midline of body below dorsal soft rays, and extending past caudal base.[4] Pelvic fins little behind pectorals; [1] caudal fin subtruncate, pectoral fins bluntly pointed, pelvic fins pointed.[4]

Pigmentation: In life pink, pinkish white,[1] or dark red; also described as salmon above, rosy pink on lower sides and venter; pectorals red or orange, pelvics rosy, caudal yellow or orange; [13] dorsal and anal fins reddish.[4]

Maximum length: Reported to 305 mm TL.[1]

DISTRIBUTION AND ECOLOGY

Range: Both sides of the Atlantic, both coasts of Africa; also India, Australia, Indochina, the Philippines, Japan and the Hawaiian Islands. In the western Atlantic from Gulf of Maine to Rio de Janeiro, Brazil, including the northern and southeastern Caribbean.[1,3,4,9]

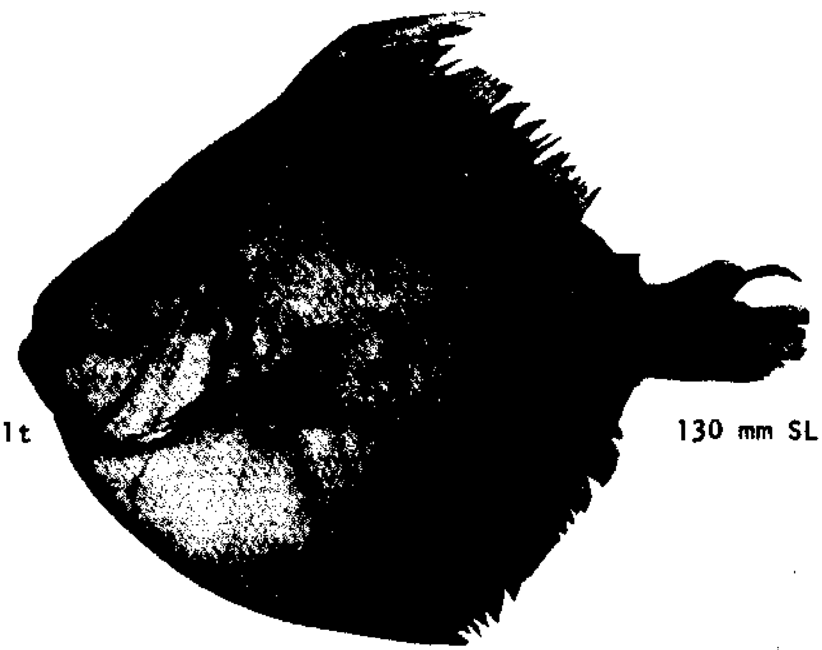
Area distribution: Coastal waters of Virginia and New Jersey.[2,4,10,11]

Habitat and movements: Adults—a pelagic, offshore species.[4] Depth 40 [1] to 236 m,[4] and possibly to 256 m,[8] but most abundant at ca. 60 m; [14,15] occur in water up to 594 m deep.[4]

Larvae—Offshore, pelagic.[4]

Juveniles—A specimen 35 mm long collected at 73 m.[8]

A Adult



130 mm SL

Fig. 11. *Antigonia capros*, Deepbody boarfish. A. Adult, 130 mm SL. (*A, Berry, F. H., 1959: fig. 11.*)

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

Size range described, 3.0–4.75 mm.

Larval stage characterized by well-developed, serrated preopercular and cranial spines. At 3.0 mm urostyle flexed, rays evident in caudal fin, dorsal fin developing. At 4.75 mm pectoral fin rays well-developed.[3]

Pigmentation: At 3.0 mm stellate melanophores over dorsal portion of gut, few on head; eyes pigmented. At 4.75 mm additional melanophores on gut and head and few melanophores formed near mouth.[3]

JUVENILES

Minimum size described, 44.5 mm.

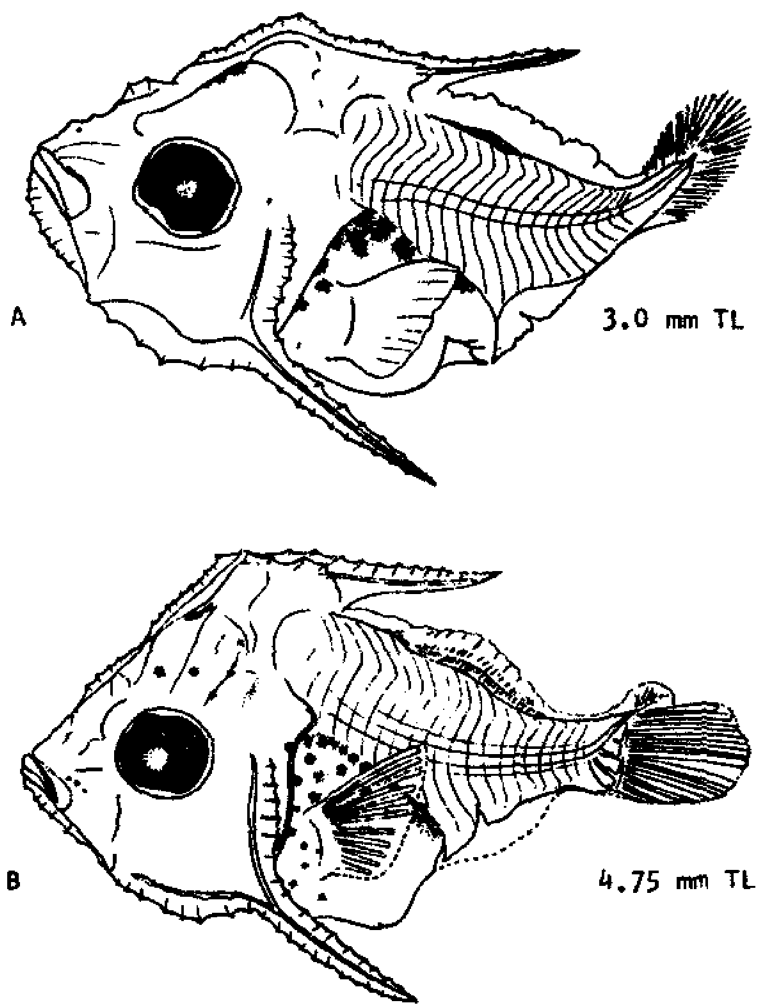


Fig. 12. *Antigonia capros*, Deepbody boarfish. A. Larva, 3.0 mm TL. B. Larva, 4.75 mm TL, dorsal rays just beginning to form. *(A, B, Nakahara, K., 1962: figs. 1–2.)*

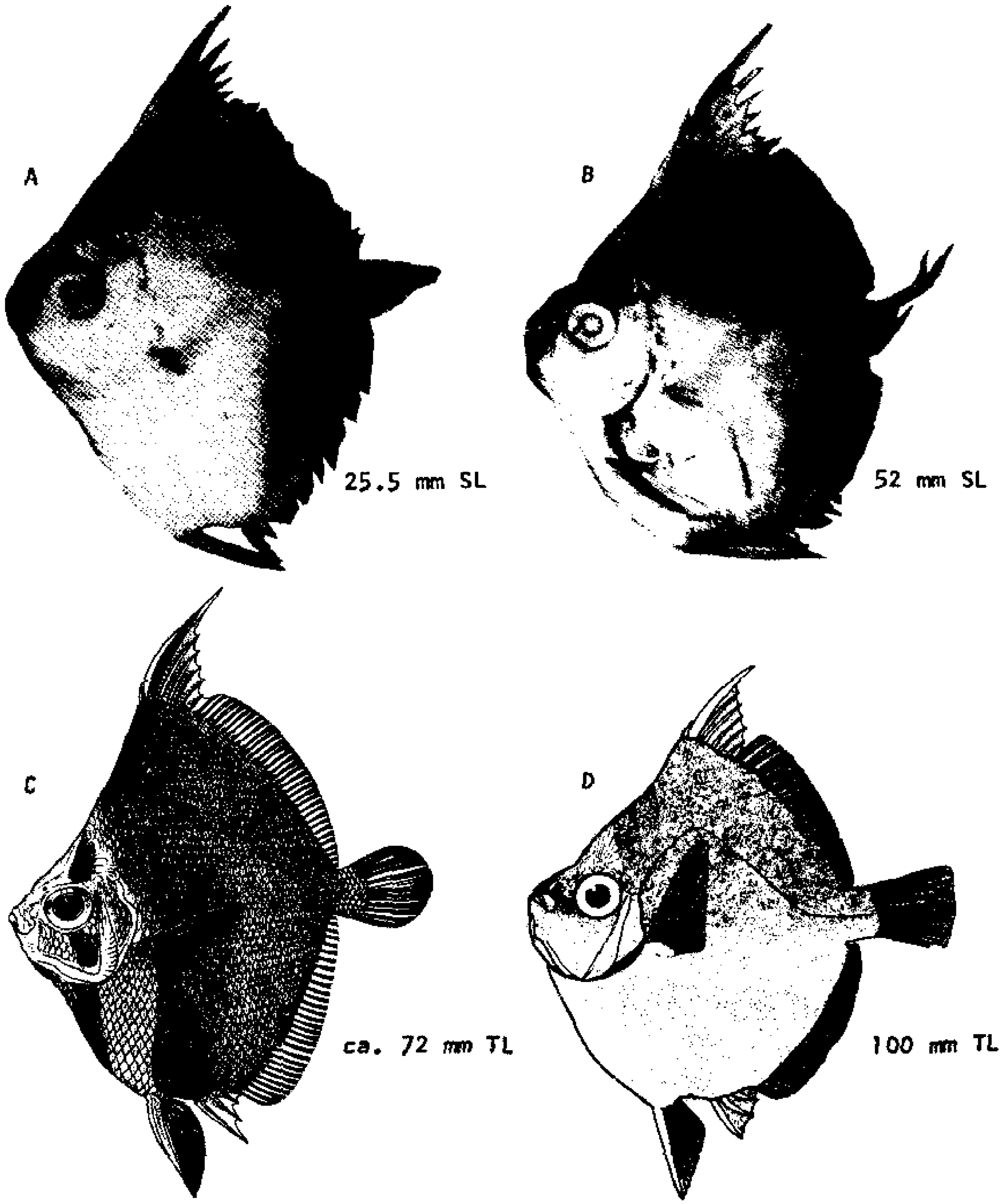


Fig. 13. *Antigonia capros*, Deepbody boarfish. A. Juvenile, 25.5 mm SL. B. Juvenile, 52 mm SL. C. Juvenile, ca. 72 mm TL. D. Possible juvenile, 100 mm TL. (*A, B, Berry, F. H., 1959: fig. 10. C, Fowler, H. W., 1934: fig. 8. D, Cervigon M., F., 1966: fig. 102.*)

Depth increases in proportion to SL with growth to ca. 50 to 60 mm.[4]

Pigmentation: At 44.5–65.5, dark red bar extended through eye, another from spinous dorsal base to pelvic insertion, and a broad bar-like mass of dark pigment beginning at middle of soft ray bases and diminishing in intensity on caudal peduncle; snout and interbar spaces colored silvery pink; fins reddish; distal part of pelvic fins black.[4]

At ca. 75 mm (when fresh) head and pectoral region from pectoral fins to pelvic fin bases bright silvery white; a rose-pink band ventrally from above eye, then below eye and along front edge of breast and belly; a broad median rose-pink band from below dusky area, immediately behind spinous dorsal base, to base of pelvic and lower front base of soft anal; on body a broad posterior dark area to caudal peduncle; dorsal and anal bright salmon colored; pelvics pale, terminating with dark or neutral gray; iris silvery white.[12] Young of unspecified length with pectoral fins yellow, and dorsal yellow or orange.[13]

AGE AND SIZE AT MATURITY

No information.

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Anthias nichoisi
Centropristis philadelphica
Centropristis striata
Epinephelus itajara
Epinephelus morio
Epinephelus nigritus
Epinephelus niveatus
Mycteroperca microlepis

sea basses
Serranidae

FAMILY SERRANIDAE

The sea basses, of which there are numerous genera and approximately 370 species, occur in tropical and temperate waters throughout the world. Although a few species occasionally enter freshwater, the members of the family are primarily bottom dwelling marine fishes.

In serranid fishes the opercle has three spines, the central of which is the most developed; the preopercular margin is usually serrate; the lateral line is complete and continuous; the scales are usually ctenoid, although sometimes cycloid; the caudal fin is typically rounded, truncate, or lunate, and only rarely forked; and there are usually 24 or 25 vertebrae.

Hermaphroditism occurs frequently among serranid fishes. Some species of *Hypoplectrus* and *Serranus* are simultaneously male and female; while various species of *Centropristis*, *Epinephelus*, and *Mycteroperca* may be initially functional females producing normal eggs and later transform into functional males.

Sea basses typically produce small, buoyant eggs having a single oil globule. In early larvae of *Serranus* and *Anthias* the yolk projects forward beyond the head and the oil globule is positioned anteriorly. Older larvae of these genera are characterized by well-developed preopercular spines and precocious development of the dorsal and pelvic spines. In larvae of the regional species, *Epinephelus niveatus*, the 2nd dorsal and pelvic spines are extremely elongate and conspicuously serrated, and there is a robust spine at the angle of the opercle. In larvae of *Centropristis striata*, on the other hand, development of the dorsal and pelvic spines is not precocious, and the preopercular spines are only moderately developed.

Anthias nicholsi (Firth), Rosy bass

ADULTS

D. X, 15; A. III, 7; scales in lateral line 33, between first dorsal spine and lateral line 4, between middle dorsal spines and lateral line 2; gill rakers 8 + 29.[2]

Proportions as times in SL: Depth 2.3, head 3.0–3.3. As times in HL: eye 3.3, snout 3.3.[2]

Profile slightly concave, humped at nape; mouth oblique; maxillary scarcely reaching middle of eye. Narrow bands of small teeth in jaws, the outer series somewhat enlarged; several moderately developed canines in front of jaws, the largest of these near middle of lower jaw; conspicuous bands of teeth on vomer and palatines; tongue mostly smooth. Caudal fin forked; pelvic fins long and pointed, reaching anterior soft anal rays.[2]

Pigmentation: In life rose-red [2] or pink; [3] body with 3–4 lengthwise yellow stripes and a deep blue blotch in middle of back at base of first dorsal; [2] an ill defined band of yellow along base of dorsal; [3] belly silvery whitish [2] or whitish with median lemon yellow band from symphysis to pelvics; [3] head with radiating stripes of yellow and red; [2] iris crimson red, with lemon yellow ring around pupil; dorsal brilliant red basally, chrome to lemon yellow distally; anal pink basally, yellow distally; caudal brilliant chrome yellow, outer half of each lobe pink; pectorals salmon; pelvics with pink anterior edge, remainder of fin yellow.[3]

Maximum length: 191 mm TL.[2]

DISTRIBUTION AND ECOLOGY

Range: Virginia [2] and New Jersey.[1]

Area distribution: Off Cape Henry, Virginia and off Chesapeake light vessel; [2] also New Jersey.[1]

Habitat and movements: Adults—recorded depths, 73 and 91 m. Distance out, 80 km.[2]

Larvae—no information.

Juveniles—no information.

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

No information.

AGE AND SIZE AT MATURITY

No information.

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Fig. 14. *Anthias nicholsi*, Rosy bass. A. Adult, 191 mm TL. (*A, Firth, F. E., 1933: 159.*)

Centropristis philadelphica (Linnaeus), Rock sea bass

ADULTS

D. X, 11; A. III, 7; [2,19] C. 9 + 8, procurrent rays 9–10 + 7–9; [19] P. 15–20, mode 18; V. I, 5; vertebrae usually 24 [2] (10 + 14 [19]), rarely 22 or 23; predorsal scale rows 11–19, usually 13–16, scale rows on cheek 9–11; total gill rakers (including tubercles) 17–22, usually 19–21; gill rakers on lower limb ca. 13; pyloric caeca 6.[2]

Proportions as percent SL: Depth 25–33; pelvic insertion to lateral line 19–26; pelvic insertion to snout 31–46; dorsal length 17–35; dorsal origin to caudal base 65–76; dorsal origin to occiput 14–20; anal length 15–27; pelvic length 19–24.[2]

Body robust, somewhat elevated; head large, slightly compressed; mouth large, terminal, lower jaw slightly projected; [2] maxillary extended to posterior edge of pupil.[3] Anterior nares with large dermal flap. Opercle drawn out into thin flap; middle opercular spine well-developed, lower poorly developed, upper barely visible. Teeth in bands in jaws, outer and inner teeth slightly to moderately enlarged, no canines; patch of teeth on vomer V-shaped, patch on palatines long and narrow.[2,3,4] Top of head, suborbital, maxillary, lower jaw, and snout naked; scales extended onto fins; small scales at base of soft dorsal membranes in single rows, scales at base of anal membranes in single rows extending one-half or less the length of membranes; dorsal spines with long fleshy filaments at tips, the filaments often as long as the spines; caudal fin distinctly 3-lobed in large specimens, with upper and middle lobes greatly produced; last one or two anal rays greatly elongate in spawning males.[2,3,4]

Pigmentation: In life, olivaceous, greenish, or brownish above, whitish below; 6 or 7 faint broad brown bars on back and sides extending obliquely forward to level of middle of pectorals; lateral bars almost obsolete along lateral line and interrupted by two light longitudinal lines which originate above and behind pectoral fins; snout and upper parts of head with numerous brownish red spots and lines, three or four of which are parallel and extend from eye to snout; interspaces between these lines usually light blue; upper lip reddish or reddish brown; tip of lower jaw purplish; a dark blotch on opercle anteriorly; throat lemon yellow; peritoneum silvery; spinous dorsal translucent with light bluish shadings and indistinct whitish or dusky longitudinal streaks and a large dark blotch on membrane of last spine; dorsal filaments bright scarlet; soft dorsal margined with reddish brown and with bluish white and reddish brown spots; anal white with median streak of sulfur yellow and dark terminal band; caudal translucent, marbled with brownish red and bluish white spots and margined above with brownish red; pectorals translucent; pelvics whitish, partly dusky, or uniform black.[2,3,4]

Maximum length: 254 mm.[17]

Range: Cape Henry, Virginia to Palm Beach, Florida; on Gulf coast, Cape Haze, Florida to Brownsville, Texas.[2]

Area distribution: Near Cape Henry, Virginia.[2]

Habitat and movements: Adults—both deep and shallow water; offshore in rocky areas and near edges of coral reefs; inshore in harbors, bays, shallow brackish lakes, and rivers.[2,3,4,6,16] Recorded salinity range, 7.7 [1]–37.9 ppt.[12] Recorded temperature range, 10.0–34.9 C.[10] Maximum reported depth, 35–42 m.[9]

Larvae—no information

Juveniles—specimens 12 mm long and longer inshore [2,18] in channels, shallow bays, and sounds; [11,12] common in water 3.6 to 36 m deep in summer along Gulf coast.[2,15] Recorded salinity range 7.2 [6]–36.7 ppt.[7] Recorded temperature range 10.0–34.9 C.[13,14]

SPAWNING

Location: May enter harbors to spawn.[4]

Season: Gulf coast specimens with well-developed gonads between November and March; Atlantic coast specimens with developed gonads from February to June.[2]

Fecundity: No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Minimum size described, 40 mm.[2]

At ca. 50 to 60 mm caudal rounded; [4] at ca. 100 mm mid-caudal ray somewhat produced; [2] at ca. 150–165 mm

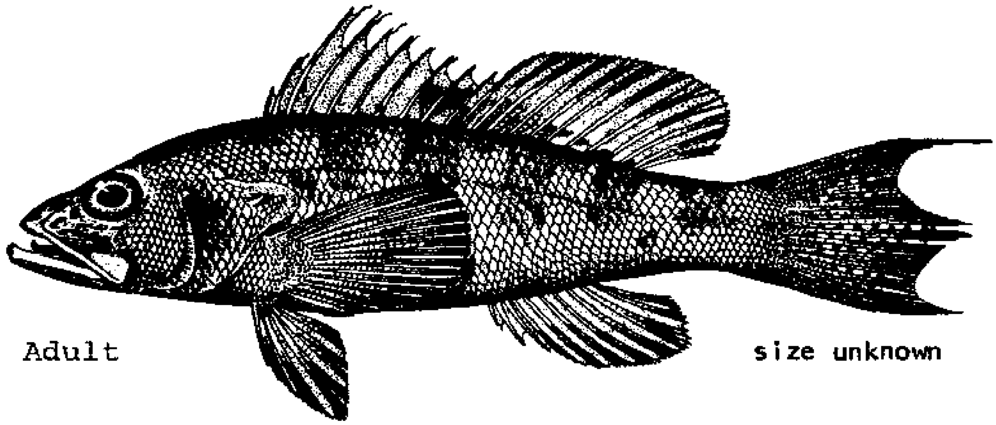

Fig. 15. *Centropristis philadelphica*, Rock sea bass. A. Adult, size unknown. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 501.*)

caudal strongly trilobate and ending in filamentous streamers.[4]

Pigmentation: At 40 mm similar to adult.[2]

AGE AND SIZE AT MATURITY

No information.

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Centropristis striata (Linnaeus), Black sea bass

ADULTS

D. X, 11; A. III, 7;[1,2,11] C. 34–35 (9–10+9+8+8);[44] P. 14–20, usually 16–19 (range 18–20 in Atlantic coast form); V. I, 5; transverse scale rows 48–50;[2] predorsal scale rows 8–17, usually 11–15; scale rows on cheek about 11; scale rows on opercle about 8–9; scales from dorsal origin to lateral line 5–8, from anal origin to lateral line 12–18;[11] vertebrae 10+14[44] (rarely total of 23); total gill rakers (including tubercles) 20–29 (23–29 on Atlantic coast); gill rakers on lower limb 14–19;[11] branchiostegal rays 7;[1,11] pyloric caeca 4–7.[11]

Proportions as times in TL: Head 2.5–2.65, depth 2.4–2.95.[2] Proportions as percent of SL: dorsal origin to snout 33–42, anal origin to caudal base 38–48, dorsal fin origin to lateral line 10–14, caudal peduncle depth 12–15, head length 37–44, interorbital width 5–9, snout length 8–14, orbit length 6–12, upper jaw length 14–21 (14–18 on Atlantic coast), pectoral length 23–30 (26–30 on Atlantic coast), dorsal origin to caudal base 66–76, dorsal origin to occiput 12–23, anal length 17–27, pelvic length 21–31.[11]

Body moderately stout,[3] robust, somewhat compressed; back slightly elevated anteriorly; head large,[1,11] flat topped;[3] snout moderately pointed; mouth large, oblique;[2] lower jaw sometimes slightly projecting;[11] maxillary extended to about middle of eye[2] or to posterior margin of pupil.[10] Nares with large dermal flap. Opercle drawn out as broad, thin flap; middle opercular spine well-developed, lower one poorly developed, upper one a small blunt protuberance; posterior border of preopercle finely serrate, the angle and lower border with larger teeth, some antrorse. Teeth in jaws in wide bands, outer and inner teeth slightly enlarged, no canines; teeth only slightly depressible; vomerine teeth in crescent shaped patch; palatine teeth in long, narrow patch. Top of head, suborbital, maxillary, lower jaw, and snout naked; scales extended somewhat onto fin bases; small scales at base of soft dorsal membranes in two rows, scales at base of anal membranes in single row extending one-third length of membranes.[11] Spinous and soft dorsal fins continuous;[3] vertical fins of males somewhat filamentous during spawning season;[8] caudal sometimes rounded, sometimes trilobed, and with one upper ray produced in larger specimens.[1]

Pigmentation: In life smoke gray, dusky brown, or blue-black above, slightly paler below; centers of scales pale blue or white, forming longitudinal stripes along back and sides; sides sometimes mottled or with dark and light vertical crossbars; bluish streaks sometimes in front of or below eye; dorsal blue-black with series of pale spots or streaks; caudal dusky or dark blue streaked or mottled with pale markings; anal almost entirely pale; pelvic fins bluish gray, the rays pale; pectoral grayish. Breeding males with bright blue around eyes and adipose hump, body with vivid hues of fluorescent blue and green; females during breeding season brownish, whitish, or yellow-green.[2,3,8,27,32]

Maximum length: 610 mm or more.[3]

DISTRIBUTION AND ECOLOGY

Range: Cape Ann, Maine[12] to Cape Canaveral, Florida; also the Florida Keys and along the Gulf coast from Pensacola to Placida, Florida (the latter population sometimes considered a separate subspecies).[11]

Area distribution: Coast of New Jersey;[1,16,41] Delaware,[39,40] including the Delaware River estuary;[25] bays along Atlantic seaside of Maryland;[5,24] Virginia;[6] Chesapeake Bay north to Solomons and Tangier Sound;[2,7] up Potomac River as far as Wicomico River.[4]

Habitat and movements: Adults—around pilings, wharves, and wrecks;[2,3,18] also on offshore ledges and banks;[12,22] generally over rough hard bottoms[1,3,20] of rock and coral;[2,12,15] associated with offshore coral patches at least as far north as North Carolina;[45] also associated with oyster beds.[6] Enter rivers in Florida;[9] possibly winter in torpid state in deeper water around rocky bottoms.[3,30] Minimum depth, "a few feet";[3] maximum depth, taken at an average tow depth of 196 m.[17] Minimum salinity, 7.7 ppt. Temperature range ca. 8.0[3]–29.8 C,[9] but rarely found below 10 C.[11]

In northern part of range migrate shoreward and northward in summer, offshore and southward in winter;[1,3,12,28] in latitudes of Chesapeake Bay offshore over rocky bottoms near edge of continental shelf in winter,[37] inshore (Chincoteague and Sinepuxent bays) April to November;[5] from New Jersey to southern New England inshore April to December,[12] but earliest appearance varying with latitude, thus in New Jersey in April, at Woods Hole, Massachusetts, early May,[36] with inshore movement governed by temperature of 8.9–10 C.[33] Move inshore in Long Island area in mid-October;[38] in New Jersey in water up to 36 m deep in summer, move out to 55 to 120 m in winter.[26] Individual fish apparently remain more or less stationary in southern parts of the range. Tagged specimens still in the area of release after 8 to 341 days of freedom.[48]

Larvae—under experimental conditions newly hatched larvae made vertical movements and were randomly spaced at mid-depths; those which remained on bottom died.[8] Recorded from inlets[1] and bays[10] as well as from

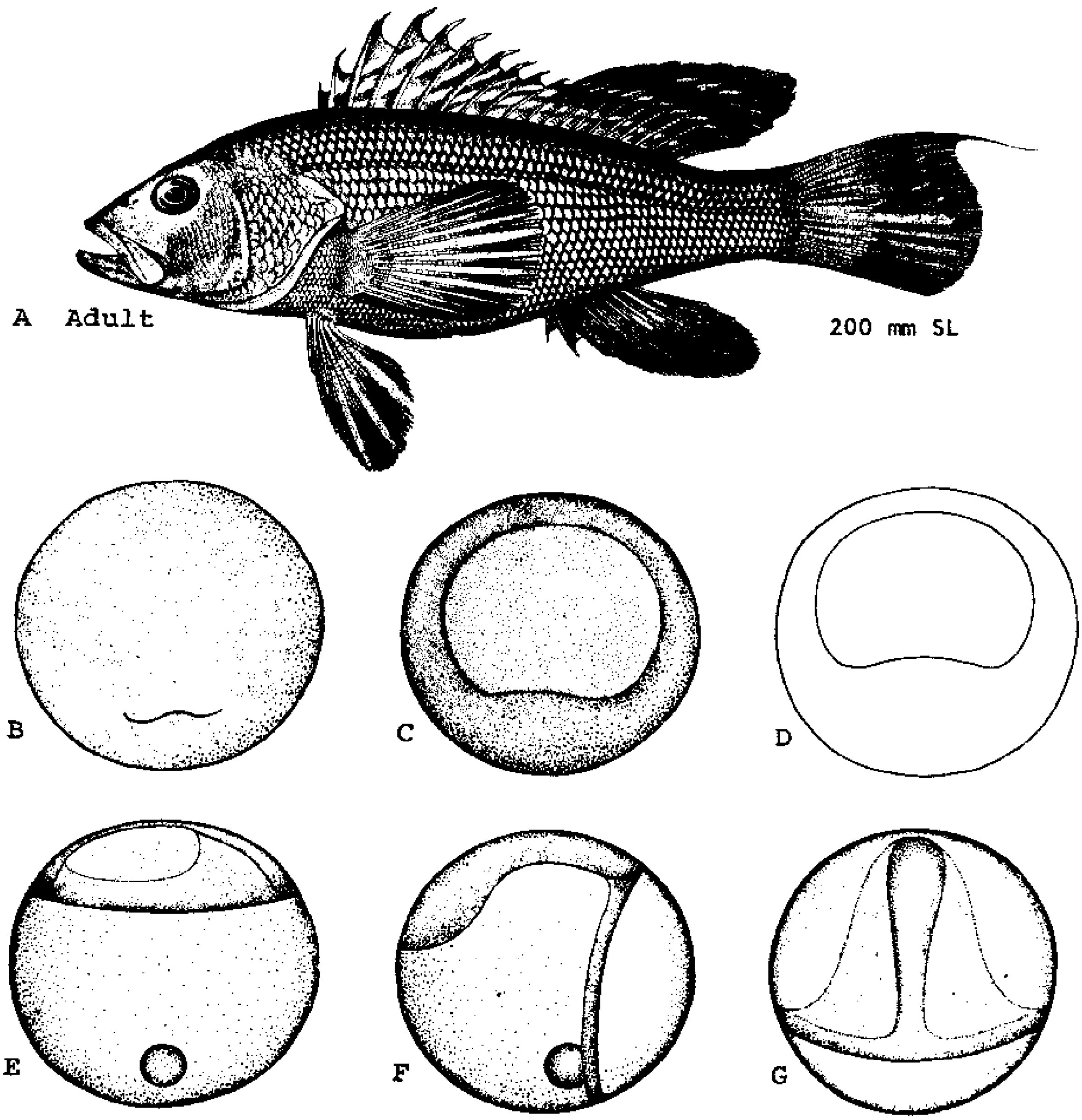

Fig. 16. ***Centropristis striata***, Black sea bass. A. Adult, 200 mm SL. B. Egg, 16 hours, germ ring forming. C. 17 hours, germ ring complete. D. 20 hours, embryo just forming, dorsal view. E. Same as D, lateral view. F. 25 hours, blastoderm over 2/3 yolk, lateral view. G. Same as F, dorsal view. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 500. B-G, Wilson, H. V., 1891: figs. 32–37.*)

offshore waters.[42] Large larvae apparently found deeper than smaller larvae. Maximum depth between 18–33 m in water 15 to 51 m deep. Salinity (based on surface salinities): 30.3–34.6 ppt. Temperature: recorded in water having surface temperatures of 14.3–28.0 C and bottom temperatures of 8.3–26.6 C. Distance out, 4 to 82 km.[1] Young migrate inshore at a very early stage of development;[42] specimens larger than 13 mm assume demersal or estuarine habits.[1]

Juveniles—inshore[1] in bays[12,16] and estuaries;[1] at ca. 25 to 35 mm in eel grass, also in channels of shallow bays around wharves and landings[36,37] and near inlets in estuaries;[1] juveniles of unspecified size sometimes in fish traps and oyster trays;[25] small juveniles over oyster beds.[1,12,30] Depth: small specimens at 3.6 to 14.6 m.[14]

Recorded temperature range, 13.5[47]–31.0 C;[46] recorded salinity range, 30.5[47]–36.6 ppt.[46]

Juveniles leave estuarine nursery areas in fall and return in spring;[1] young inshore April to December at Orient, New Jersey.[12]

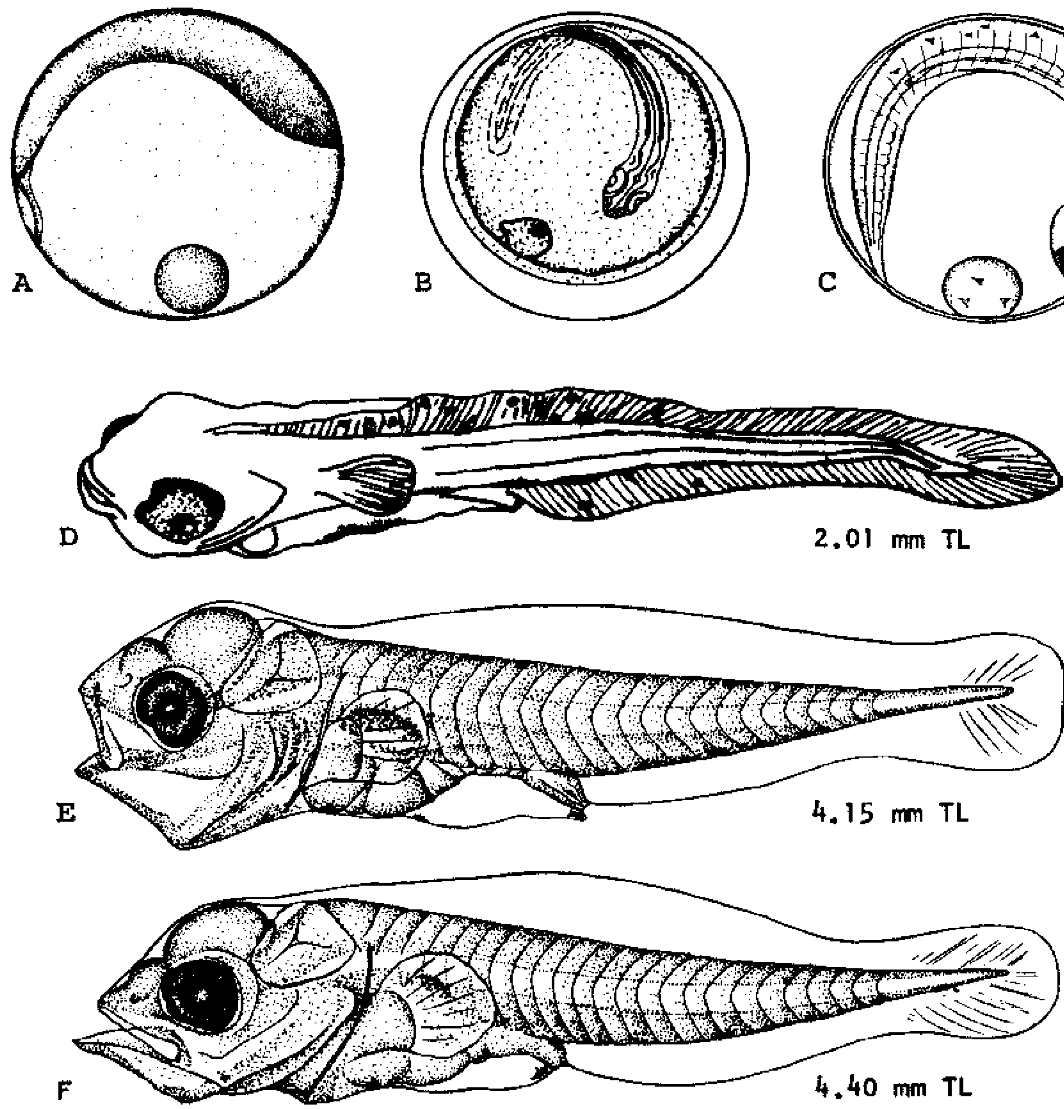

Fig. 17. *Centropristis striata,* Black sea bass. A. 31 hours, blastopore nearly closed. B. A more advanced embryo, ca. 23 hours old, eye, lens, somites formed (this egg probably was incubated at a different temperature than previous one). C. 65 hour embryo, choroid fissure, otocyst, pigment formed. D. Yolk-sac larva, 2.01 mm TL, 54 hours after hatching. E. Larva, 4.15 mm TL. F. Larva, 4.40 mm TL. (*A, C, Wilson, H. V., 1891: figs. 38, 151. B, Hoff, F. H., Jr., 1970: fig. 8. E, F, Original drawing, Alice J. Lippson.*)

SPAWNING

Location: Offshore coastal waters.[1,42]

Season: Northward progression in spawning season. In Florida February to April (although secondary sexual characteristics appear in males in late November);[8] in South Carolina running ripe in late March;[34] in North Carolina May and early June;[1,2,20] in latitudes of Chesapeake Bay late May;[1,2,11] in New Jersey mid-May to end of June;[1,26,27] at Woods Hole, Massachusetts, May to first of July.[12,18,37]

Fecundity: No information.

EGGS

Location: Pelagic,[1] buoyant,[3,12] floating at surface[29] (although Earll maintained that they sink rapidly in salt water[34,35]).

Fertilized eggs: Round; clear;[1] very transparent;[22] diameter 0.9 to 1.0 mm[1,22,30,34,35,37] (although one author stated that the "average" diameter is 1.0 mm[12]); egg membrane variously described as smooth,[1] thin and horny;[21] nonadhesive;[12] yolk transparent;[21] oil globule single; perivitelline space narrow.[1]

EGG DEVELOPMENT

Development at 23 C (the Hoff series):

At 23 hours	neural streak clearly visible; optic cups, lenses, myomeres evident; oil globule apparently with some pigment.
At ca. 38 hours	hatching.[8]

Development at unspecified temperature (the Wilson series):

"a couple of hours" after fertilization	blastodisc formed.
At 16-cell stage	segmentation cavity clearly formed.
At ca. 4 1/2 to 9 1/2 hours	late segmentation stage.
At 16 hours	germ ring forming.
At 17 hours	germ ring complete.
At 20 hours	embryo just forming.
At 25 hours	embryo more advanced, anlagen of heart evident, blastoderm over 2/3 yolk.
At 33 hours	optic vesicles formed.
At 49 1/2 hours	somites forming (anteriorly to posteriorly), Kupffer's vesicle no longer evident.
At 53 hours	notochord becomes vacuolated.
At 65 hours	pigment on body and oil globule, choroid fissure evident.
At 75 hours	Wolffian ducts formed, hatching.[21]

Incubation period:

At 10 C	ca. 5 days[12]
At ca. 15 C	5 days[29,31,37] or ca. 75 hours[21]
At 16 C	75 hours[1]
At 23 C	38 hours[1]

Note on incubation: Wilson reported that some eggs (ca. 2/3 of his) sank and rose again not long before hatching (at ca. 40 hours in series which took ca. 75 hours to hatch).[21]

YOLK-SAC LARVAE

Specimen described, 2.01 mm;[8] yolk sac almost gone in 3 to 4 days.[21]

Between 2 and 5 mm, body proportions remain fairly constant with slight increase in snout and eye length and body and caudal peduncle depth relative to SL. Proportions as percent SL: Head length averages about 33.[1]

Mouth open a "couple of days" after hatching;[21] oil globule anterior;[22] at 1 day yolk mass limited to anterior part of trunk. Pectoral buds not evident until a couple of days after hatching,[21] but developed and with rays at 2.01 mm.[8] Liver evident 1 day after hatching, urinary bladder shortly after hatching.[21]

Pigmentation: At hatching transparent,[22] eye not pigmented. At ca. 54 hours (2.01 mm), eye pigmented, large chromatophores evident in dorsal and ventral finfold and apparently on gut.[8]

LARVAE

Size range described 2.1 mm SL[1]–9.7 mm TL (AJL).

Proportions as percent SL: Head length averages ca. 33 at 2 to 5 mm, 37–38 at 5–12 mm; eye length 9–10 throughout stage; snout length 6–11 at 2–6 mm, constant thereafter; preanal length 50 at 5 mm, 58 at 10 mm; greatest depth 25–27 throughout stage; depth at caudal peduncle 6–14 at sizes of 4 mm and greater.[1]

At 5.0 mm gill rakers evident as few tubercles on gill arch; at 6.0 mm, 9 rakers on lower limb, none on upper; at 10.6 mm, 10 on lower, 4 on upper. Branchiostegal rays first evident at ca. 4.5 mm; at 6.5 mm adult complement formed. At 5.0 mm teeth fairly closely spaced along premaxillaries and medially on dentaries. Preopercular spines evident at sizes greater than 5.0 mm.[1]

At 4.0 mm dorsal finfold forward at least to nape; at 5.0 mm finfold conspicuously elevated halfway back on

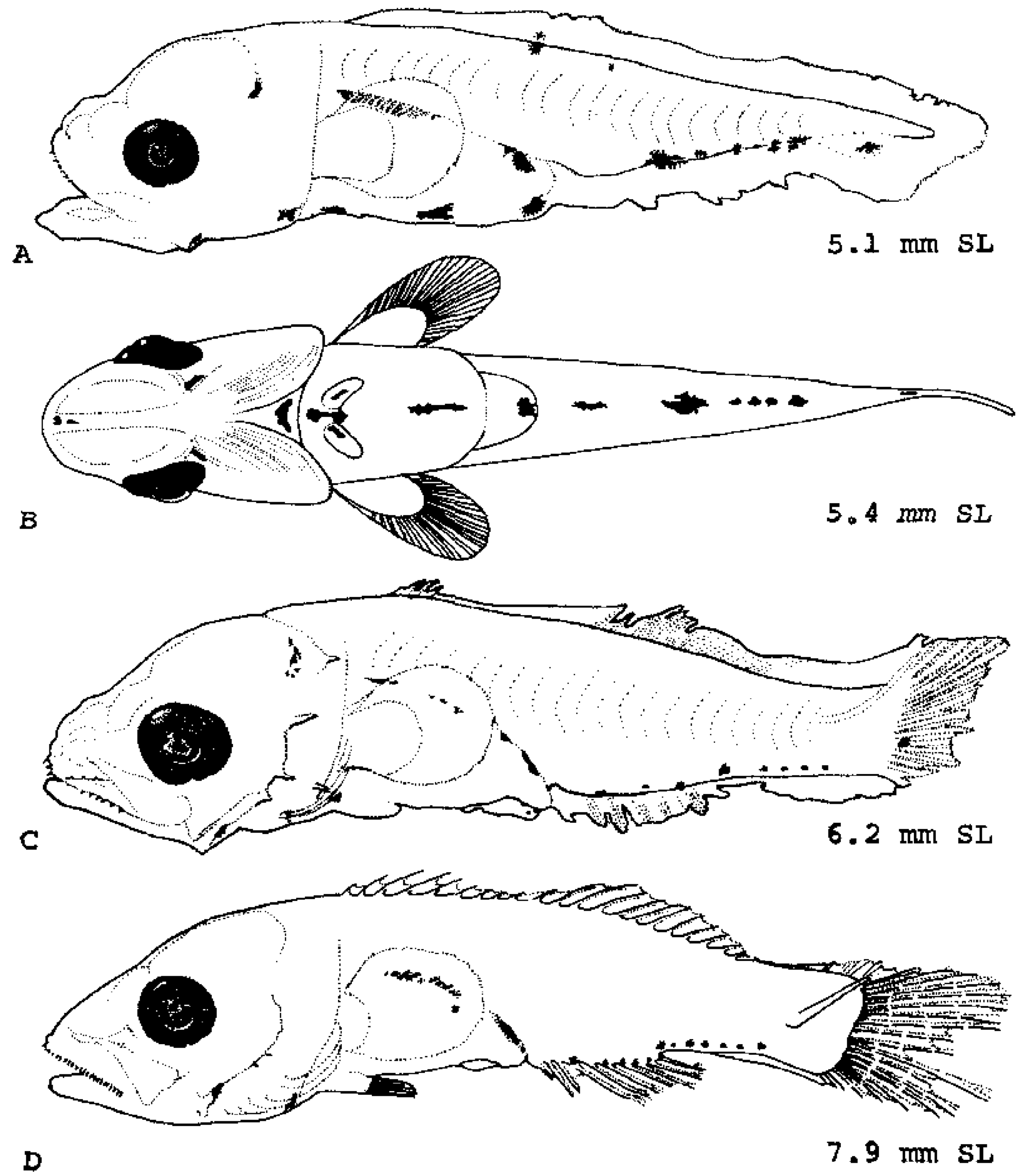

Fig. 18. *Centropristis striata,* Black sea bass. A. Larva, 5.1 mm SL. B. Larva, 5.4 mm SL, ventral view. C. Larva, 6.2 mm SL. D. Larva, 7.9 mm SL. (*A-D, Kendall, A. W., Jr., 1972: figs. 3, 9, Joan Ellis, delineator.*)

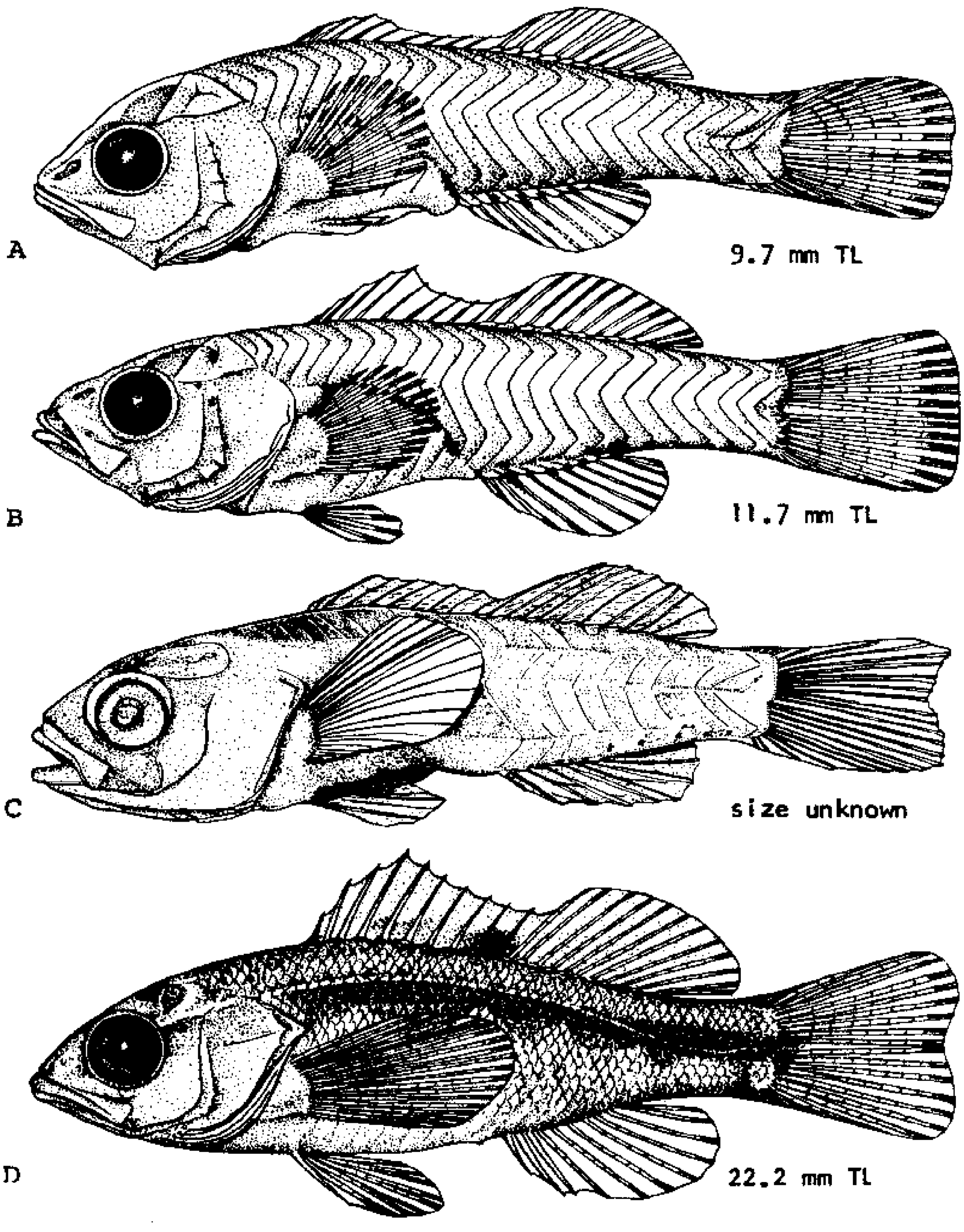

Fig. 19. *Centropristis striata*, Black sea bass. A. Larva, 9.7 mm TL. B. Larva, 11.7 mm TL. C. Juvenile, size unknown. D. Juvenile, 22.2 mm TL. (*A, B, D, Original illustrations, Alice J. Lippson. C, Original illustration, Nancy S. Smith.*)

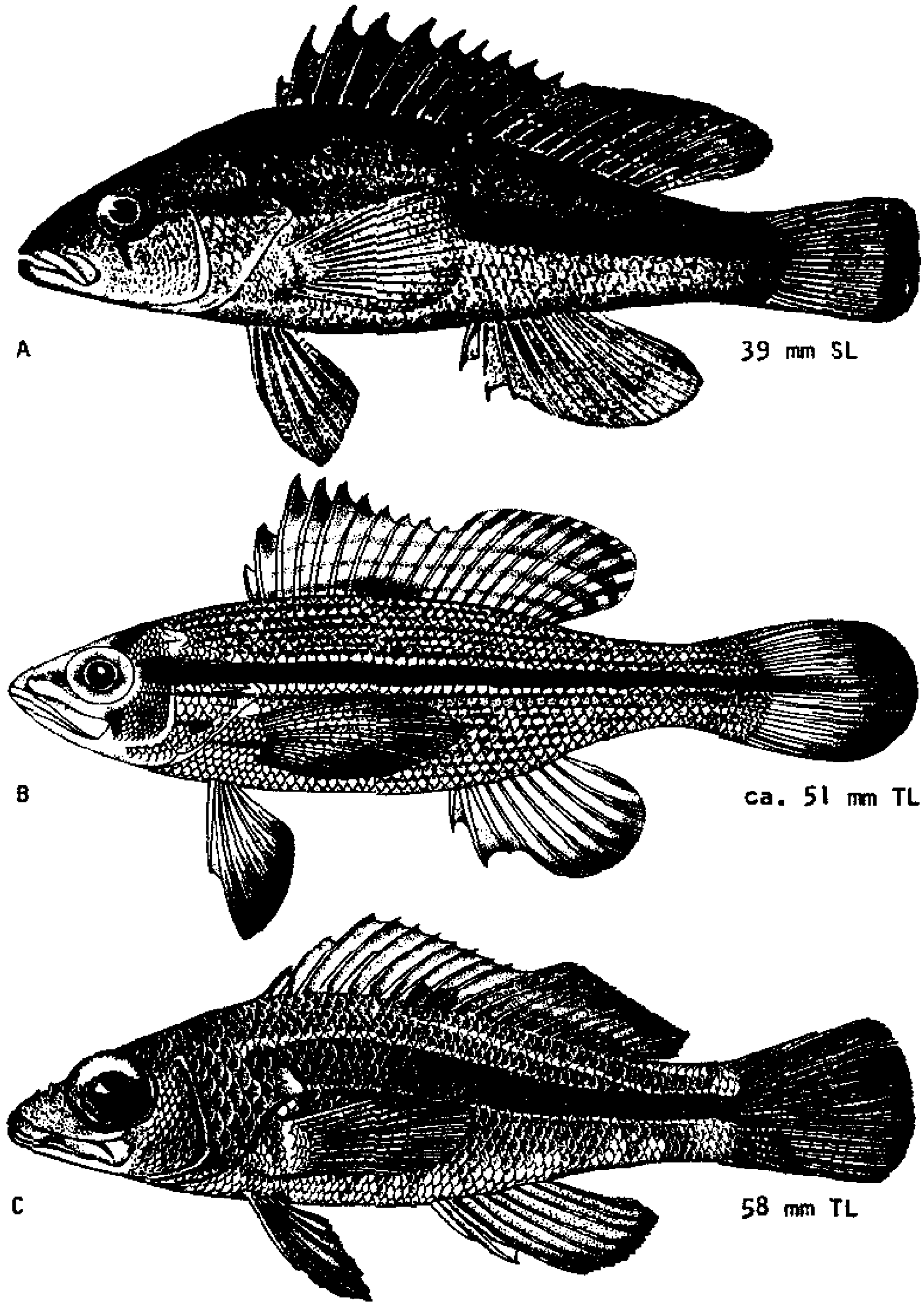

Fig. 20. *Centropristis striata,* Black sea bass. A. Juvenile, 39 mm SL. B. Juvenile, ca. 51 mm TL. C. Juvenile, 58 mm TL. (*A, Bean, T. H., 1889: fig. 12. B, Fowler, H. W., 1945: fig. 63. C, Hildebrand,* S. F., *and W. C. Schroeder, 1928: fig. 144.*)

body; posterior part of dorsal finfold obliterated at 5.5–6.5 mm. Dorsal spines and rays first evident at 4.6–5.5 mm; adult complement at 8.7–9.0 mm; rays branched and serrated at 8.0 mm. Anal rays first evident at 5.5 mm, spines at 6.5 mm; adult complement reached at minimum of 7.0 mm, at which stage some rays are branched.[1] Incipient rays in caudal at 4.15 (AJL); primary upper and lower rays evident at 5.0 mm, secondary lower rays at 6.5 mm, and secondary upper rays at 8.7 mm; adult complement at 9.0 mm; caudal fin with rounded homocercal outline at 8.0 mm.[1] Incipient pectoral rays at 4.15 mm (AJL); most rays formed at 6.5 mm; fin adult-like at 9.0 mm. Pelvic buds first evident at 4.0 mm; rays and spines developing at 5–6 mm, more or less adult-like at 8.0 mm, but failing to reach vent throughout stage. Urostyle oblique at 5.5 mm. Ossification of vertebral column first evident at 4.5–5.0 mm with ossification proceeding posteriorly; at 6.5 mm ossification complete except 2 or 3 vertebrae anterior to urostyle; urostyle ossified at 6.0 mm; ossification complete at 7.0 mm.[1]

Pigmentation (general description at unspecified sizes): Some spots at base of developing anal; a prominent spot at posterior end of anal, followed by 4 to 6 smaller spots along mid-ventral line, the series extended to base of caudal; an enlarged spot at caudal base; in later stages small spots dorsally and ventrally in caudal region.[1]

At 4.0 mm SL a spot formed on each angular.[1]

At 4.15 mm 2 prominent chromatophores on back, one just anterior to level of anus and one on middle of tail; few pigment spots on lower part of body and preanal finfold; a series of chromatophores along ventral edge of tail; dense chromatophores over gut (AJL). At 4.4 mm dorsal spots obliterated, otherwise pigment as in previous stage (AJL). At 5.0 mm SL one spot ventrally on median cartilage between dentaries and urohyal, and, sometimes, a second spot posterior to this; a dendritic spot just anterior to symphysis of cleithra; usually a spot between bases of pelvics; a variable number of spots on posterodorsal covering of cerebellum, and, usually, a pair of spots internally on posterior surface of midbrain.[1]

At 6.0 mm SL gut pigment reaches exterior as a large intense spot at posterior region of renal tract.[1]

JUVENILES

Minimum size described, 10 mm.[1]

Proportions as percent SL at 91 to 136 mm SL: Greatest depth 30.0–38.5, depth at caudal peduncle 13.5–14.5, maxillary 17.0–18.5, snout 11.5–12.5, eye 8.5–9.5, interorbital distance 7.0–8.5.[16] Proportions as percent SL at unspecified size: Head length 34–45; eye length 9–10; preanal length, maximum 65.[1]

At 10.0 mm premaxillary teeth closely spaced and slightly recurved, those on dentaries enlarged, widely spaced posteriorly.[1] Scales not evident at 11.7 mm (AJL).

In young soft parts of dorsal and anal proportionately

Fig. 21. *Centropristis striata*, Black sea bass. A. Juvenile, 59.6 mm SL, Atlantic population. B. Juvenile, 59.0 mm SL, Gulf of Mexico population. (*A, B, Miller, R. J., 1959: figs. 9–11.*)

much lower than in adult.[2] In small specimens caudal asymmetrical,[11] prolongation of upper lobe of caudal just beginning at ca. 150–175 mm.[32]

Pigmentation: Juveniles of Gulf coast population and, to lesser extent, Atlantic coast population, with dark smudges on jaws; young of both populations with dark stripe from opercular flap to caudal fin; Atlantic form with black spot at last dorsal spine.[11]

At 12 to 13 mm SL a series of ca. 6 small melanophores along lateral line, also a few spots at origin of dorsal fin; a band of minute melanophores from angular past eye to anterior part of cerebellum; also several large spots on anterior halves of cerebral hemispheres, and from eye to opercular flap.[1]

At 22.2 mm a broad lateral band developing along side, arched upward and more or less following contour of lateral line; a patch of pigment at caudal base; a dark blotch at midpoint of dorsal fin, and small melanophores visible throughout dorsal fin (AJL).

At ca. 50 to 60 mm dorsal blotch well-developed at base of last two or three spines; lateral dark stripe well-developed; some specimens with traces of crossbands on body.[32]

At 50 to 75 mm as in previous stage; body brownish above; lateral stripe dark brown or black; brick red markings below eye; spinous dorsal dusky, with dorsal spot present or absent; soft dorsal with 3 or 4 rows of brick red spots; caudal and anal with reddish markings; pectorals salmon; pelvics plain.[2]

At ca. 100 mm lateral stripe, markings on dorsal fin as in previous stage.[43]

Ryder described 3 well defined transverse bands of pale yellow chromatophores at equal intervals on body and tail of young fish.[22]

Fig. 22. *Centropristis striata*, Black sea bass. A. Markings on jaws of young *Centropristis striata melanus* from the Gulf of Mexico. (*A, Miller, R. J., 1959: fig. 12.*)

AGE AND SIZE AT MATURITY

Males and females mature at 4 years, although adipose hump of males not well-developed until 6 years of age; protogynous hermaphroditism occurs.[23,27] Females mature at 185 mm, males 190 mm (although adipose hump does not develop until at least 250 mm SL).[27]

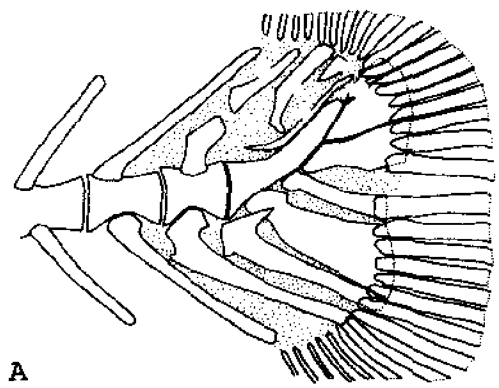

Fig. 23. *Centropristis striata*, Black sea bass. A. Caudal skeleton, larva, 11.8 mm SL. (*A, Kendall, Arthur W., Jr., 1972: fig. 7.*)

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Epinephelus itajara (Lichtenstein), Jewfish

ADULTS

D. XI,[2,15] (14)[1] 15–16; A. III, 8;[2,14,15] P. (total both sides) 36–38; V. I, 5; scales in transverse series, 2 counts reported, 85–89 and 110–114, scales above lateral line 13, below ca. 25–34; total gill rakers (19) 22–24.[15]

Proportions as percent SL: Head length 34.5–42.1; snout length 7.3–9.7; length of orbit 2.7–7.4; body depth 29.2–36.1; caudal peduncle depth 12.4–13.1; dorsal spine III 9.0–12.3.[15] Eye 10–12 times in head;[3] interorbital width greater than orbital diameter; posterior nostril about equal to or somewhat larger than anterior nostril.[2]

Body very robust,[8] thick,[15] almost round in cross-section;[9] skull broad; interorbital area broad;[6,15] eyes noticeably small; mouth very large; maxillary extended well beyond eye;[3] jaws with slightly enlarged canines. Scales very rugose,[15] those of lateral line modified by strong radiating ridges;[9] maxillary with prominent scales. Vertical fins rounded; dorsal spines short (tuberculate in large specimens) with interspinous membranes well notched;[15] insertion of pelvic fin under or somewhat behind lower end of pectoral base; pelvics shorter than pectorals.[2]

Pigmentation: Mottled gray or greenish,[9] brownish yellow,[3] black, brown, or white, sometimes with greenish cast.[6] Head, body, and fins with dark brown or black spots.[2,15] *In large specimens spots up to ca. 12 mm in* diameter;[9] spots initially on anterior parts, becoming more widespread with age;[6] specimens up to ca. 1220 mm long[9] with 5 irregular oblique bars on upper sides;[3] fins dark.[10]

Maximum length: Ca. 2137 mm; maximum weight variously reported 308 to 340 kg.[3,10]

DISTRIBUTION AND ECOLOGY

Range: In western North Atlantic, Chesapeake Bay, Virginia[1] and possibly north to Massachusetts[20] (although apparently rare north of Florida, JDH) to Brazil,[6,15,20]

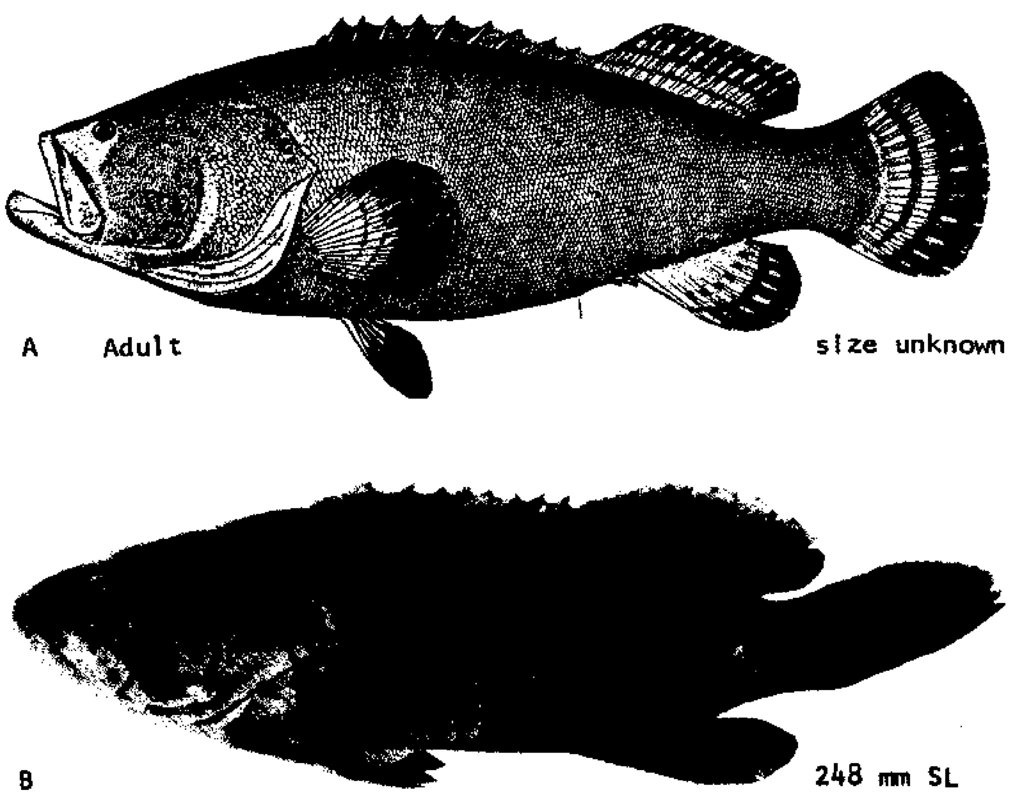

Fig. 24. *Epinephelus itajara*, Jewfish. A. Adult, size unknown. B. Juvenile, 248 mm SL. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 487. B, Smith, C. L., 1971: fig. 26.*)

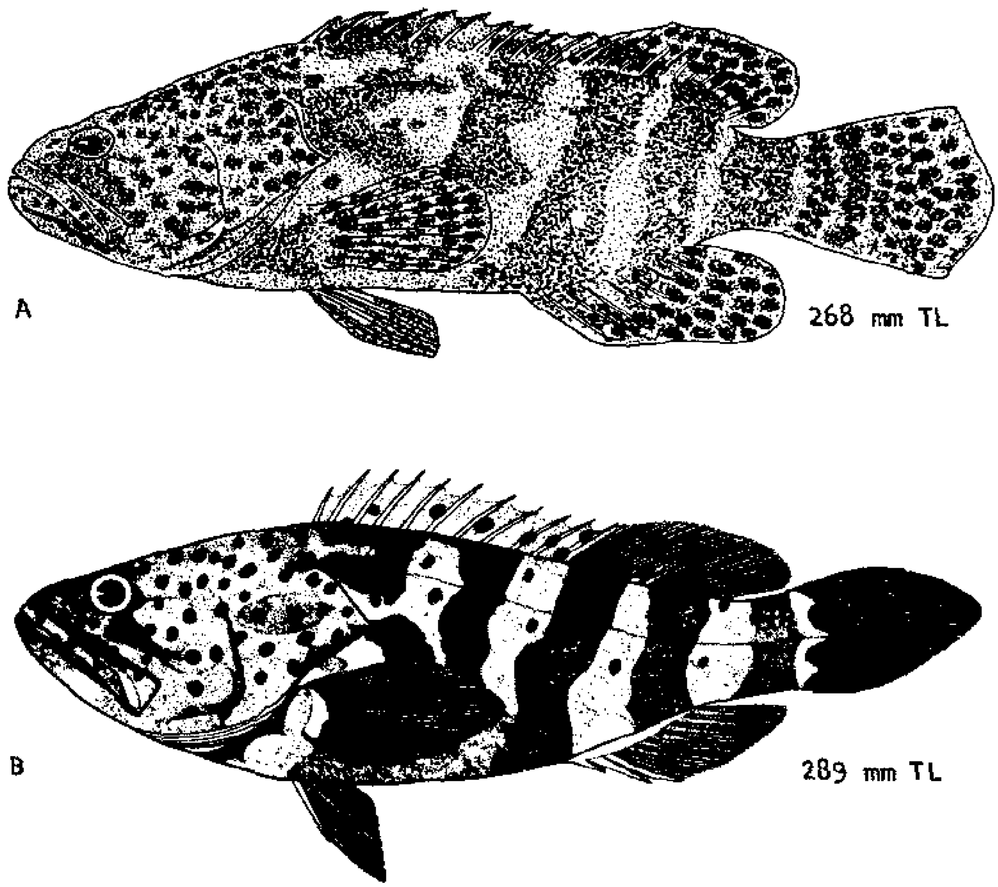

Fig. 25. ***Epinephelus itajara***, Jewfish. A. Juvenile, 268 mm TL. B. Juvenile, 289 mm TL. (*A, Böhlke, J. E., and C. C. G. Chaplin, 1968: 283 © Academy of Natural Sciences of Philadelphia, with permission of authors and publisher, Joan Ellis, delineator. B, Cervigon M., F., 1966: fig. 123.*)

including Bermuda [6] and the West Indies; throughout the Gulf of Mexico; [15] in eastern Pacific from Mexico to Peru.[26] A record from Siam is questioned.[15]

Area distribution: Approximately 6.4 km southeast of New Point Comfort Light, Chesapeake Bay, Virginia.[1]

Habitat and movements: Adults—offshore on rocky reefs,[4] in holes,[8] under ledges, in underwater caves,[6] and around wrecks; [4] inshore around jetties and pilings,[8,10] in deep channels, and in river estuaries; sometimes lie with tails exposed among mangrove roots at waters edge; [8] recorded from a boil of discolored water from an underwater spring; [11] found in association with coral [5,6] and sponge and over bottoms of sand, shell,[7] and rock.[5] Recorded salinity range 25 [8]–39.1 ppt. Temperature range 18.5–30.0 C.[22] Maximum recorded depth 29 m.[7]

Some individuals fairly stationary (a tagged specimen in Florida moved only 9.6 km in 557 days),[16] although there are apparently annual offshore-inshore movements along coast of Texas,[21] and the record from Chesapeake Bay suggests long distance excursions north of the normal range (JDH). The species becomes gregarious during the spawning season.[5]

Larvae—no information.

Juveniles—specimens less than 30 mm long in turtlegrass beds and around red mangroves (FDM). "Small" in shallow water close to shore,[9] in bays and around bulkheads of bridges. Typically at salinities greater than 25 ppt,[8] but a possible juvenile at 21.8 ppt; [19] maximum recorded salinity 37.5 ppt.[20] Recorded temperature range, possibly 23.6 C [19] to maximum of 30 C.[20] Minimum depth, less than 1 meter (FDM).

SPAWNING

Season: July and August in southern Florida; [5] a large female from Chesapeake Bay caught August 13 had apparently spawned recently.[1]

Fecundity: No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Minimum size described, 107 mm.[15]

Eye 6 times in head at ca. 150 mm;[3] orbit diameter greater than least interorbital width in specimens 150 mm or smaller, less in larger specimens.[2]

Pigmentation: Young and very young described as yellowish or warm yellow–brown, speckled with numerous small black spots and with mottled pattern or with about 6 darker, sometimes obscure, irregular oblique bars on sides.[9,10,13,15,18] At 107 mm top of head and snout, suborbital region, and upper part of cheek dusky, irregularly spotted with small and medium sized spots, especially along edge of preopercle. Upper lip dark at tip, crossed posteriorly by 3 dark lines. Two black spots on maxillary. Two vertical dark bars extended downward from spinous dorsal, converging at level of upper margin of pectoral, and becoming narrow below. A broad bar extending from anterior margin of soft dorsal to front of anal; a similar bar from posterior part of soft dorsal to posterior anal rays. Two dark bars across caudal peduncle. Underside of head and body lighter than dorsum and without conspicuous markings. Caudal with dark bar on its basal third, its distal areas with several irregularly placed black spots, each surrounded by a dusky circle in a darker background; dorsal fin crossed by extensions of body bars and with prominent black spots just above bases of most of the membranes; anal dusky throughout but with body crossbars extended onto anterior and posterior parts and with dark marginal band; pectorals crossed by 4 more or less regular rows of spots, otherwise pale; pelvic fins dusky throughout and with 2 dark spots near base.[15]

At 268–289 mm, as in previous stage, but pectoral fin with numerous large black spots.[6,17]

Ground color of specimens up to ca. 915 mm long, greenish to tawny.[16]

Pattern of dark bars on sides retained to at least 1000 mm.[2]

AGE AND SIZE AT MATURITY

Specimens weighing up to 23 kg are considered juveniles;[8] a male 1602 mm long was apparently mature. Protogynous hermaphroditism occurs;[12] a male ca. 1830 mm long contained numerous remnants of ova.[9]

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Epinephelus morio (Valenciennes), Red grouper

ADULTS

D. XI [4,7,16] (rarely X), (15) [4] 16–17 [4,7,16] (18 [4]); A. III, 8 [4]–10 (usually 9); [4,16] C. (principal rays only) 9+8; [4] P. (total on both sides) 33–36; V. I, 5; total gill rakers 22–25 [4] (8–9+15–16 [7]); pyloric caeca ca. 26; total vertebrae 24.[4]

Proportions as times in TL: Head 2.5, depth 2.7. As times in head length: eye 5.5; [10] posterior nostril about equal to or slightly larger than anterior.[5,7] Proportions as percent SL: Head length 40.2–42.0; snout length 9.9–11.6; length of orbit 7.0–11.5; body depth 33.6–37.7; caudal peduncle depth 10.6–11.5.[5]

Body robust,[4] deep, compressed; [10] head large, moderately pointed, the anterior profile rather steep and nearly straight; [13] preopercle finely serrate; [10] mouth rather large,[13] maxillary reaching past eye.[10] Vertical fins rounded; second dorsal spine longest; dorsal interspinous membrane not notched; caudal fin slightly lunate.[4]

Pigmentation: Reddish brown,[4] olive brown, or olive gray on sides,[10] rarely with orange cast; with [4] or without [7] scattered white spots [4] or pale grayish white blotches; [5,10] sometimes a banded pattern; [7,11] lower part of head and breast salmon,[10] light pink or dirty white; sides of head reddish [4] and with scattered orange-brown [10] or black spots; [4] inside of mouth red [5] or orange; [10] pupil green; [5] iris golden.[10] Vertical fins generally described as margined with dark pigment [4,6] or with broad edge of blue-black and narrow pale borders. Pectorals light olive [10] or dusky; [4] pelvics dusky,[10] at least toward tips.[4]

In life pattern described as highly variable; usually a few inconspicuous light spots, uniformly dark reddish brown above, lighter below. Sometimes lighten to pale gray; sometimes with a banded pattern [11] (at least when resting [7]); sometimes uniformly dark; and sometimes, when in turtle grass, with greenish cast.[11]

Maximum length: Uncertain, possibly to ca. 915 [7] or 1220 mm.[12]

DISTRIBUTION AND ECOLOGY

Range: Katama Bay, Massachusetts to Rio de Janeiro, Brazil including Bermuda and the West Indies; center of abundance Florida and the Gulf of Mexico.[4]

Area distribution: Recorded from Virginia [13] and the coast of New Jersey.[14]

Habitat and movements: Adults—a solitary,[6] bottom species [10] found from shore out to the 150 fathom line over bottoms of smooth mud, sand, coral rubble, or broken rock; [3] frequently in crevices, or underwater limestone caverns. Maximum depth 274 m.[3] Move offshore at attainment of maturity.[7] Some inshore-offshore movement; some individuals move inshore in summer.[10] Movements are apparently limited: some individuals moved 29 km in 47–49 days; one moved 72 km in 466 days.[7]

Larvae—no information.

Juveniles—at lengths of less than 20 mm SL, planktonic; above this size, benthic.[7] Recorded from beds of turtle grass [4] and shallow reefs. Hide in crevices and shells,[7] under dead coral, or in rocky patches on *Thalassia* beds.[11] Typically inshore at depths of less than 27.4 meters.[7] Recorded salinity range, 20.7 [8]–35.5 ppt.[9] Recorded temperature range, 16.1 [8]–31.2 C.[7]

"Young" remain resident near shore for "several years" then move into deeper water,[7] but individuals tagged as juveniles and presumably recovered as adults have made extensive excursions. One tagged at 338 mm TL moved 249 km in 329 days, while another tagged at 295 mm TL moved 64 km in 1635 days.[1]

SPAWNING

Location: On offshore banks at depths of 24–91 m.[7]

Season: In Gulf of Mexico March to July, peak in April and May.[7]

Fecundity: 312,000–5,735,700 $\bar{x}$ 1,469,200 (in 14 specimens 495–667 mm SL).[7]

EGGS

Location: Pelagic [7] (by inference, JDH).

Ovarian eggs: Egg development described in 5 stages. Stage 4 eggs developed just before final maturation; diameter ca. 0.15–0.55 mm (mean 0.36 mm); yolk vesicles, "yolk globules," and zona radiata formed; zona radiata striated (but striations lost in later development). Stage 5 eggs, diameter 0.58–0.62 mm, yolk granular and with few "yolk globules," zona radiata thin, not striated.[7]

Fertilized eggs: Presumably less than 1.0 mm in diameter, and with a single oil globule.[7]

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

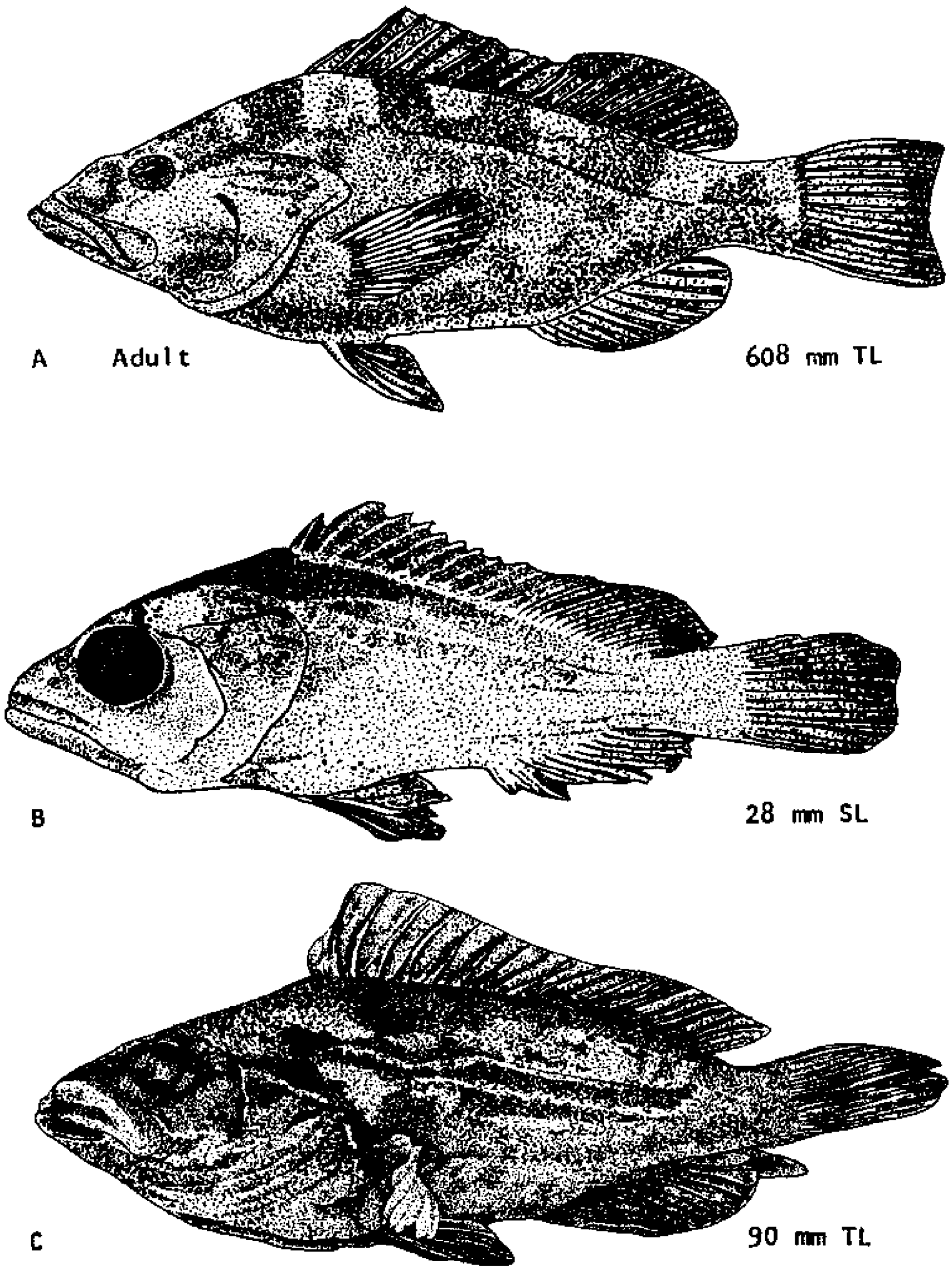

Fig. 26. *Epinephelus morio*, Red grouper. A. Adult, 608 mm TL. B. Juvenile, 28 mm SL. C. Juvenile, 90 mm TL. (*A, Böhlke, J. E., and C. C. G. Chaplin, 1968: 279 © Academy of Natural Sciences of Philadelphia, with permission of author and publishers, Joan Ellis, delineator. B, Moe, M. A., Jr., 1969: fig. 35, Joan Ellis, delineator. C, Alperin, I. M., and R. H. Schaefer, 1965: 4, Joan Ellis, delineator.*)

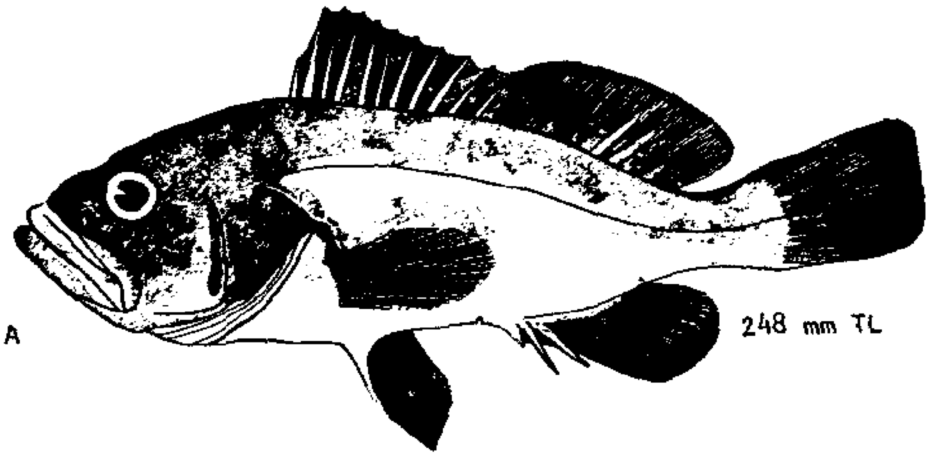

Fig. 27. *Epinephelus morio*, Red grouper. A. Juvenile, 248 mm TL. (*A, Cervigon M., F., 1966: fig. 119.*)

LARVAE

No information.

JUVENILES

Minimum size described, 23 mm SL.[7]

Proportions as percent SL: Head length 40.2–42.0, greatest depth 33.6–37.7, depth of caudal peduncle 10.6–11.5.[4] Eye 5 times in head in young.[13]

A 23 mm SL specimen with vestiges of elongate second dorsal and pelvic spines. Posterior margin of caudal convex in specimens up to ca. 150 mm.[7]

Pigmentation: Young up to 150–200 mm sometimes with ocular stripe which may extend back to dorsal fin.[11]

AGE AND SIZE AT MATURITY

Protogynous hermaphrodites; mature as females between ages 4 and 6 years; transition to males occurs between ages 7 and 14. As female at ca. 450 mm SL, transition to male after reaching 500 mm SL.[7]

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Fig. 28. *Epinephelus morio*, Red grouper. A. Juvenile, 250 mm SL. (*A, Smith, C. L., 1958: pl. 7.*)

Epinephelus nigritus (Holbrook), Warsaw grouper

ADULTS

D. X,[5,9,16] 13 [18]–15, usually 14 [5,9,16] (published counts of 11 spines are in error [9]); A. III, 9 [5,9,16] C. 33 (8+9+8+8); [16] P. (total both sides) 36–38 (39); V. I, 5; scales in transverse series, ca. 85–99, scales above lateral line, 14–19, below ca. 30–44; total gill rakers 21–25 [5] (9–11+15–16 [9]); vertebrae 10+14.[16]

Proportions as percent SL: Head length 40.2–46.5; snout length 10.2–13.2; length of orbit 4.9–10.6; body depth 32.8–43.4; caudal peduncle depth 11.1–14.3; dorsal spine III 14.8–18.6.[5]

Body robust, compressed, deepest somewhat behind dorsal fin origin; [5] diameter of orbit less than that of interorbital width; [9] posterior nostril about equal to or slightly larger than anterior nostril; [5,9] preopercle expanded into an irregular lobe at angle, with upper limb nearly at right angles to shorter lower limb; [5] mouth large; maxillary reaching beyond eye; teeth in broad bands.[17] Scales moderate; few scales on exposed surface of maxillary. Vertical fins rounded; [18] dorsal spines noticeably elongate; dorsal fin membrane deeply notched between spines in specimens larger than 350 mm; caudal margin described as straight [5] or convex; [9] insertion of pelvic fin conspicuously in advance of upper end of pectoral base.[5]

Pigmentation: Body dark red, deep chocolate brown,[5] bluish black,[17] or black; dull reddish gray below. Body and head typically without spots or bars,[5] but sides sometimes with scattered white markings.[9] Dorsal, anal, and caudal fins darkened distally, becoming almost black at margin; anal fin with shades of iridescent blue; pectorals and pelvics gray at base, darkening to blue-black toward margins.[5]

Maximum Length: 2000 mm.[17]

DISTRIBUTION AND ECOLOGY

Range: In the western Atlantic, Woods Hole, Massachusetts to southern Brazil, including Haiti and Trinidad. In the eastern Pacific, Mexico to Panama.[5,10,12]

Area distribution: New Jersey.[2,5]

Habitat and movements: Adults—found at depths of 16–464 m [5,6,11] over bottoms of rock,[13] coral,[11] mud, sand, and shell.[13] Recorded temperature range: in water in which surface temperatures varied from 16.7–27.8 C and bottom temperatures varied from 16.1–25.6 C.[11] Not known to make extensive movements (a tagged specimen did not move in 43 days).[7]

Larvae—no information.

Juveniles—recorded in bays,[1] as well as in water 27–29 m deep.[14] Recorded salinity, 29 ppt.[4] Juveniles apparently stray northward during the fall, thus specimens in New Jersey and New York in October.[2,4]

SPAWNING

No information.

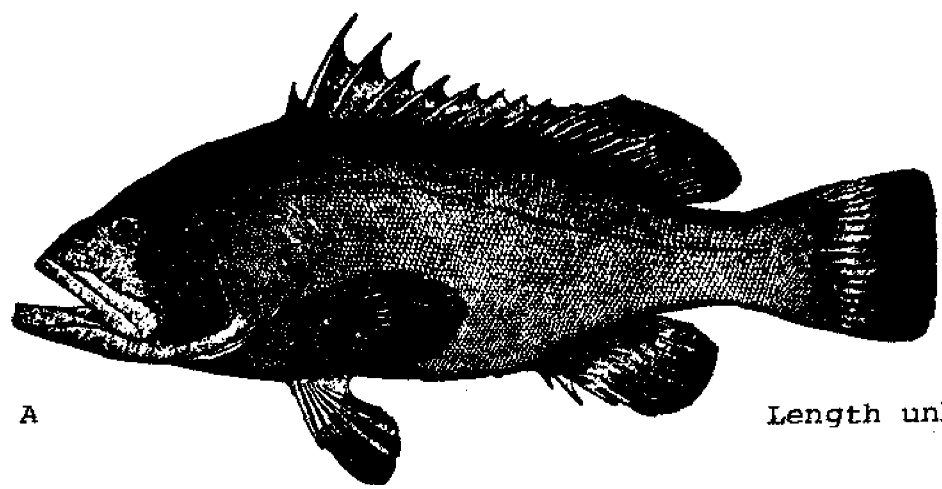

Fig. 29. *Epinephelus nigritus*, Warsaw grouper. A. Adult, length unknown. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 486.*)

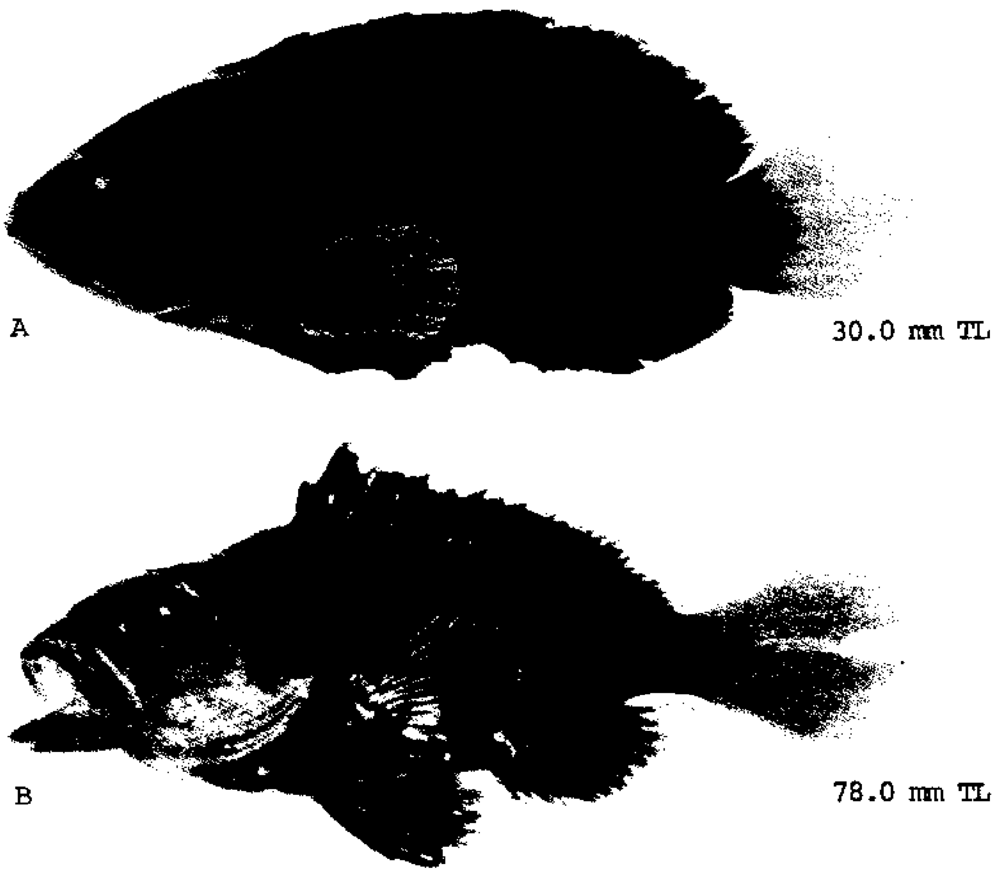

Fig. 30. *Epinephelus nigritus*, Warsaw grouper. A. Juvenile, 30.0 mm TL. B. Juvenile, 78.0 mm SL. (*A, Alperin, I. M., and R. H. Schaefer, 1965: 4. B, Smith, C. L., 1961: fig. 2.*)

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Minimum size described, 30 mm.

Pigmentation: At 30 mm tail, edges of soft dorsal and anal fins, and head much lighter than remainder of fish.[4] At ca. 87 mm outer edge of soft dorsal and anal fins clear, remainder of fin dark; caudal fin plain except at base.[8] Also at this size preserved specimens described as deep chocolate brown; lower surface of head and jaws tinted with dull brown; dorsal, anal, and pelvic fins slate colored or livid black; soft dorsal and anal fins whitish along edges; caudal white; pectoral white, chocolate at base.[8] Young or juveniles with whitish spots on body which may be evenly spaced[15] or more or less randomly distributed; caudal and pectoral fins yellow; soft dorsal fin light at margin.[5]

AGE AND SIZE AT MATURITY

No information.

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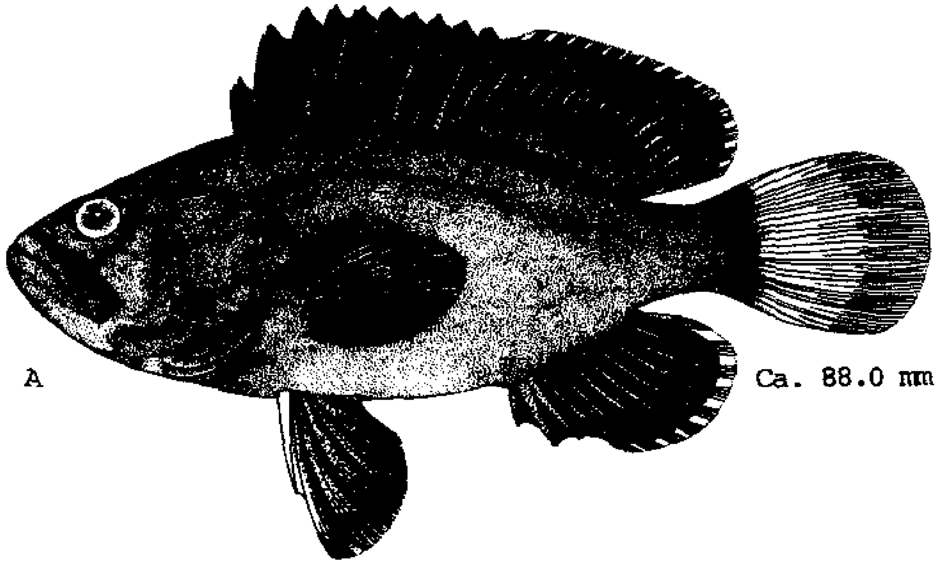

Fig. 31. *Epinephelus nigritus*, Warsaw grouper. A. Juvenile, ca. 88.0 mm TL. (*A, Fowler, H. W., 1945: fig. 262.*)

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Epinephelus niveatus (Valenciennes), Snowy grouper

ADULTS

D. XI,[2,18,22] 13[2,22]–16[18] (usually 14[2,18]); A. III, 8–10[18] (usually 9[2,18,22]); C. 33–34 (8–9 + 9 + 8 + 7–8);[22] P. (total both sides) 34–38;[18] V. I, 5;[6,18] scales in transverse series ca. 95–104; scales above lateral line 15–16, below lateral line ca. 35–44; total gill rakers 22–27;[18] vertebrae 10 + 14.[6,22]

Proportions as percent SL: Head length 41.0–45.3; snout length 9.8–12.0; length of orbit 7.9–12.4; body depth 36.3–43.4; caudal peduncle depth 11.5–13.7; dorsal spine III 13.7–19.2.[18]

Body robust; nostrils subequal, becoming enlarged in large specimens[18] (Rivas describes the posterior nostril as 3–5 times larger than anterior nostril[2]); preopercle with several strong serrae at angle.[18] Mandible extended to pupil. Scales medium; few embedded scales on exposed portion of maxillary. Teeth small, canines scattered in upper and lower jaws; teeth on vomer and palatines.[6] Vertical fins rounded; dorsal interspinous membrane notched;[18] posterior margin of caudal fin straight or slightly concave at sizes greater than 300 mm; pelvics shorter than pectorals in specimens larger than 400 mm; insertion of pelvics under or slightly in advance of pectoral base.[2]

Pigmentation: Chocolate brown above, somewhat lighter below; tip of snout, lower jaw, and upper lip dark; a dark mustache from groove above posterior tip of maxillary onto cheek; a large black saddle on caudal peduncle extending below lateral line; sides with pearly white spots arranged in regular longitudinal or vertical rows; most individuals with row of spots on middle of dorsal fin and scattered spots on head; dorsal and anal fins dusky throughout; pectoral and caudal fins clear (presumably yellow in life); pelvic fins black.[2,18]

Maximum length: Ca. 1220 mm.[4]

DISTRIBUTION AND ECOLOGY

Range: In the western Atlantic, New England to southeastern Brazil; also the Bahamas, northern Cuba, and Grenada; in the eastern Pacific, lower California and Gulf of Panama.[1,4,5,18,19]

Area distribution: New Jersey;[9,16,17,18] Ocean City and Sinepuxent Bay, Maryland.[7,8]

Habitat and movements: Adults—a shore species, but also recorded over considerable depths; found over rocky, sandy, or muddy bottoms;[4,5] also associated with coral reefs, wrecks, and other debris.[21] Maximum depth between 373 and 457 m.[18]

Larvae—pelagic, sometimes swept far out of normal range.[4]

Juveniles—inshore;[11] recorded from lobster pots. Maximum depth 11 m.[3] Move northward along the coast of the northwestern Atlantic,[14] appearing inshore at various localities from August to November.[3,11,12,13,14]

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

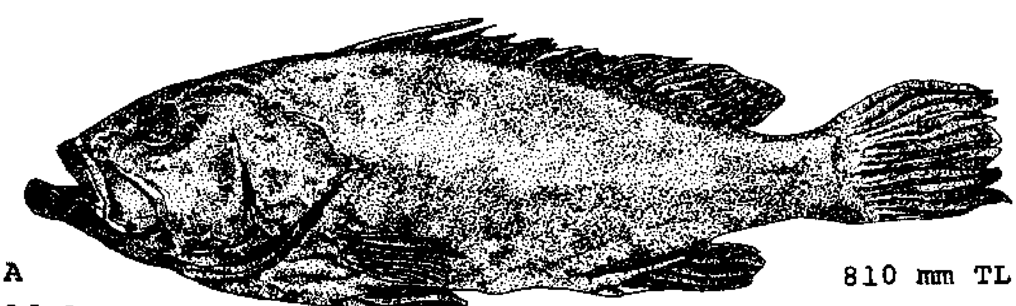

Fig. 32. *Epinephelus niveatus*, Snowy grouper. A. Adult, 810 mm TL. (*A, Smith, C. L., 1971: fig. 15, Tamiko Karr, delineator.*)

A

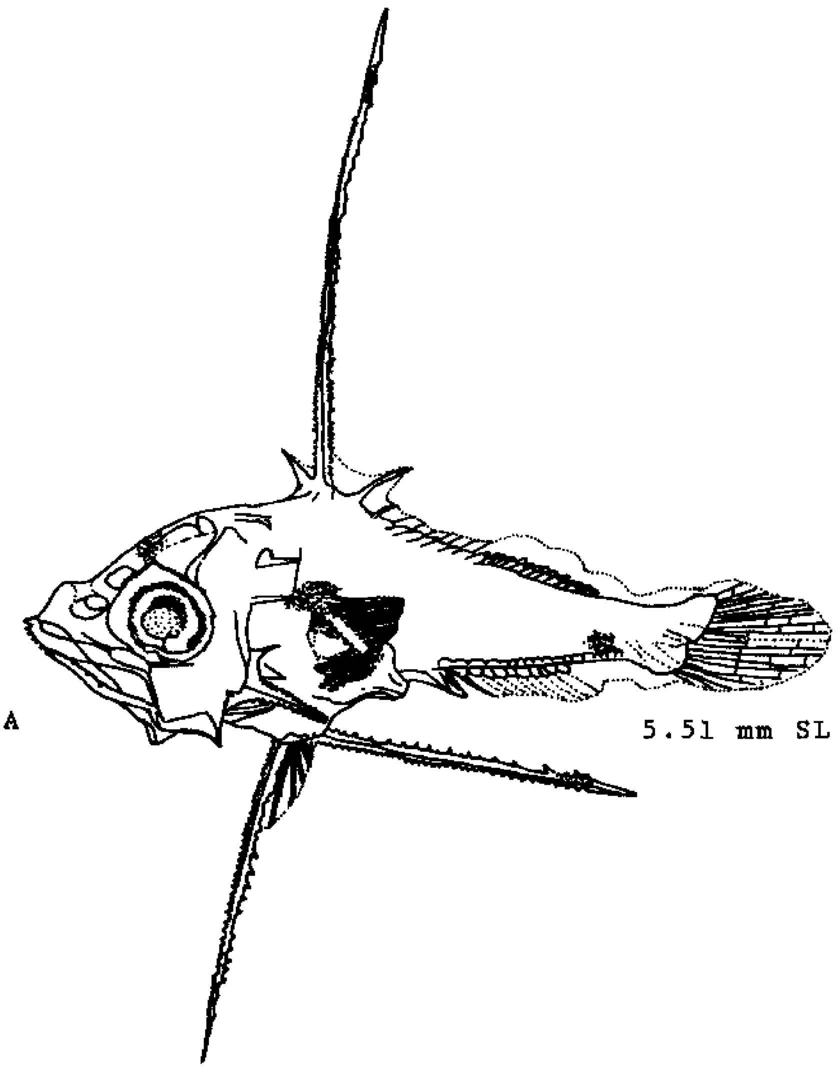

Fig. 33. *Epinephelus niveatus*, Snowy grouper. A. Larva, 5.51 mm SL. (*A, Presley, R. F., 1970: fig. 1.*)

LARVAE

Specimens described, 6.42–13.03 mm TL (although specimens larger than 11.5 mm TL may be juveniles, JDH).

Preanal myomeres 10, postanal myomeres 14, branchiostegals 7.[1]

Proportions as percent SL throughout size range of 5.51–10.3 mm SL: Depth 31.3–44.7, head length 36.2–57.0, preanal length 51.7–58.3, 2nd dorsal spine 58.4–99.4, pelvic spine 23.2–52.1, 2nd anal spine 8.3–12.6, preopercular spine at angle 13.5–19.45. Proportions as percent SL at 9.3 mm SL: pectoral fin 11, dorsal fin base 51, anal base 25.[1]

Body deep. At 9.3 mm snout angular, slightly shorter than lower jaw; gape extended almost to middle of eye; eye round; choroid fissure evident; teeth developed in smallest specimen, short, uneven, and conical at 9.3 mm. Posttemporal, supracleithrum, and opercle each with a single spine throughout stage, that of the latter located at eye level; interopercle and subopercular posterior margins each armed with one small posteriorly directed spine. Preopercular spines increase from 4 to 7 through size range of 5.51 to 10.3 mm SL. Larvae generally characterized by elongate 2nd dorsal, 2nd anal, and pelvic spines, and robust spine at angle of preopercle. Scales apparently not formed throughout stage; finfold evident at 5.51 mm SL, absent at 8.23 mm SL; urostyle distinctly oblique at 8.23 mm SL.[1]

Pigmentation: Throughout stage small chromatophores

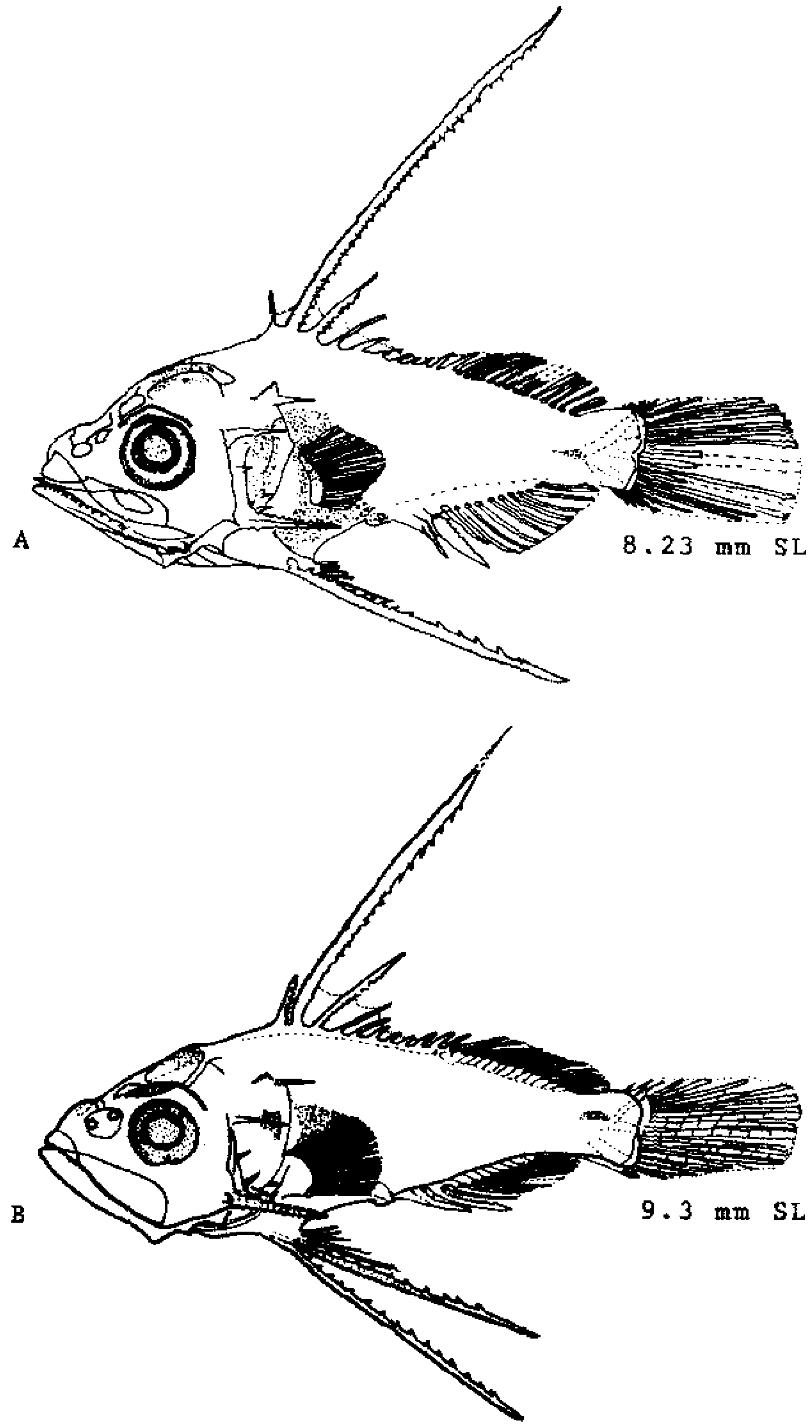

Fig. 34. *Epinephelus niveatus*, Snowy grouper. A. Larva, 8.23 mm SL. B. Larva, 9.3 mm SL. (*A, B, Presley, R. F., 1970: figs.* 2–3.)

on frontal-parietal region; eye with light and dark rings; pupil light; gut marbled; caudal peduncle with compact cluster of chromatophores (which appear to migrate dorsally as development proceeds); membrane of 2nd dorsal spine, when present, pigmented near tip.[1]

JUVENILES

Minimum size described, 55 mm.[10]

Caudal fin convex in specimens up to 300–400 mm long.[2]

Pigmentation: At 55 mm ground color dark brown (almost black); dorsal fin dark but with margin of spinous part yellow; a blue streak from eye to point above preopercular angle; 3 blue spots at base of dorsal, 4 or 5 on lateral line, about 3 each in 2 rows below lateral line, and several on sides of head behind eye.[10]

At 105–115 mm deep dusky brown with several vertical rows of pale sky blue round spots; caudal yellowish; pectorals pale.[16]

At 135 mm ground color olive green above, lighter below; membrane of outer 2/5 of dorsal bright yellow except toward end of soft dorsal lobe; pectorals and most of caudal colorless or nearly so; pelvics and anal almost black; a narrow blue line below eye to opercular angle; upper part of opercle and preopercle with several blue spots; 5 spots at base of dorsal, 6 along lateral line, 4 others below lateral line; a black saddle on caudal peduncle and a faint suggestion of a dark bar at caudal base.[10]

At 180 mm dorsal still with yellow margin.[10]

An illustration of a 255 mm specimen is typical except in showing dark rather than light spots on the body.[26]

The body spots and caudal peduncle saddle are more pronounced in specimens less than 300 mm long,[2] and

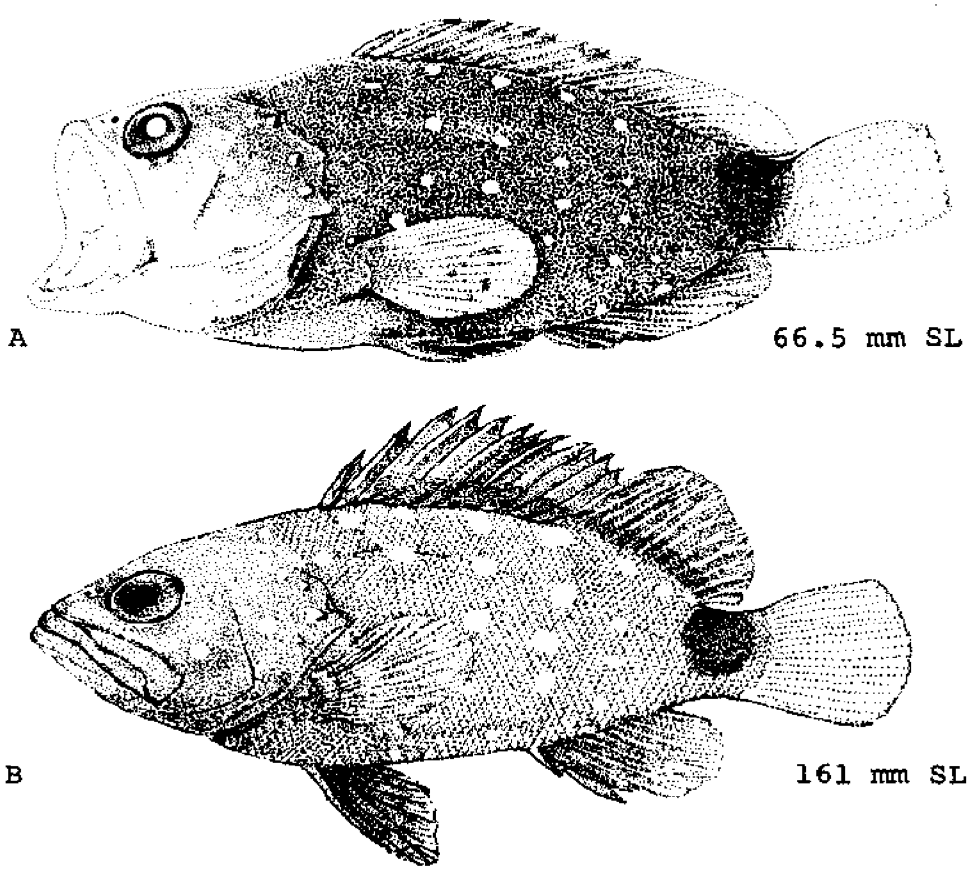

Fig. 35. *Epinephelus niveatus*, Snowy grouper. A. Juvenile, 66.5 mm SL. B. Juvenile, 161 mm SL. (*A, Smith, C. L., 1961: fig. 3, Joan Ellis, delineator. B, Böhlke, J. E., and C. C. G. Chaplin, 1968: 277 © Academy of Natural Sciences of Philadelphia, used with permission of authors and publisher, Joan Ellis, delineator.*)

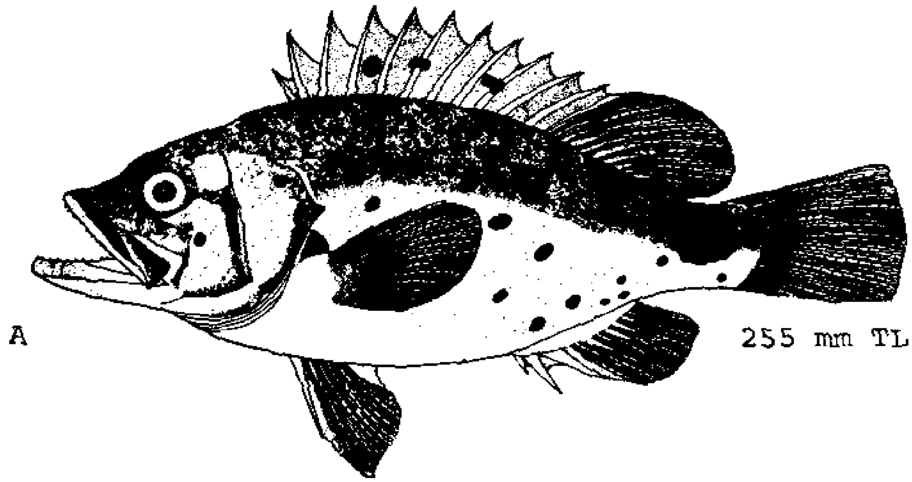

Fig. 36. *Epinephelus niveatus*, Snowy grouper. A. Juvenile, 255 mm TL. (*A, Cervigon M., F., 1966: fig. 121.*)

the spots are still clearly evident at ca. 380 mm.[4]

Preserved young show the typical mustache above the edge of the mandible and have a median row of dusky spots on the membrane of the dorsal fin.[15]

AGE AND SIZE AT MATURITY

No information.

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Mycteroperca microlepis (Goode and Bean), Gag

ADULTS

D. XI (rarely X or XII), 16–18 (usually 16–17); [20] A. III, 10–12 [20,28] (usually 11 [1,20]); C. 37 (10–11 + 9 + 8 + 9–10); [26] P. (total both sides) 32–35 (usually 34); V. I, 5; scales in transverse series 110–114; scales above lateral line (18) 21–26, below lateral line ca. 40–49; total gill rakers 21–29; branchiostegals 7; [20] vertebrae 10 + 14.[26]

Proportions as times in SL: Head 2.6, depth 3.5.[1] Proportions as percent SL: head length 38.4–40.1; snout length 9.3–11.7; *length or orbit* 5.5–7.9; *body depth* 28.9–33.6; caudal peduncle depth 11.2–12.7; third dorsal spine 11.0–12.2.[20]

Body elongate, compressed, although robust.[20] Head long, pointed.[1,15] Preopercle finely serrate above, slightly

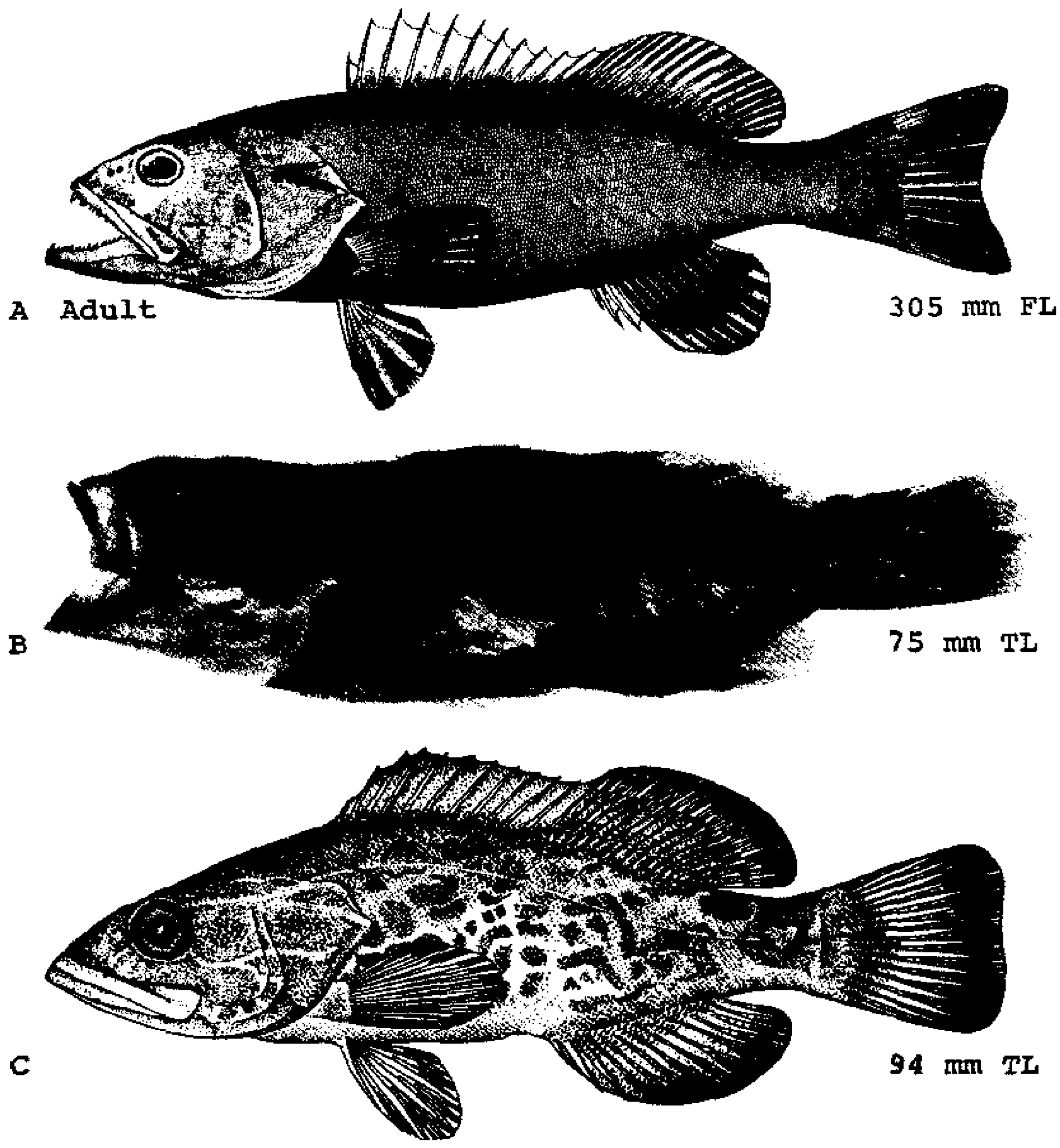

Fig. 37. ***Mycteroperca microlepis***, **Gag. A. Adult, ca. 305 mm FL. B. Juvenile, 75 mm TL. C. Juvenile, 94 mm TL. (*A, Goode, G. B.,* et al.*, 1884: pl. 167. B, Alperin, I. M., and R. H. Schaefer, 1965: 4. C, Original drawing, A. J. Lippson.*)**

notched, with strong teeth below and a developed lobe at the angle. Posterior nostril much enlarged in large individuals.[20] Mouth large; maxillary reaching beyond eye. Teeth in narrow bands, two canines in front of each jaw, the lower one smaller; [1] pharyngeal teeth coarse. Scales very small.[20] Dorsal spines slender, the 3rd and 4th largest; [1] first 3 dorsal spines not elevated into a lobe; [20] caudal fin with concave margin; pectorals reaching beyond pelvics; [1] pelvic fins without rays extended beyond membrane.[20]

Pigmentation: Body grayish [20] or brownish gray above, paler below,[1] and sometimes with irregular dusky lines radiating from eye and dark vermiculations on sides which may be arranged in definite transverse bars or quadrate groups. Dorsal dark at base shading to dusky toward margin and narrowly edged with white; caudal similar to dorsal; pectorals nearly clear, but with melanophores in upper corner which may form conspicuous blotch in large adults; pelvics dusky, but with light anterior edge and white margin. In life anal and pectoral with an iridescent blue wash.[20] Dorsal fins dark green, and indigo; caudal fins black with blue shades; pectorals green; and pelvics black.[1]

Maximum length: Unknown. Maximum weight: 22.7 kg.[1]

DISTRIBUTION AND ECOLOGY

Range: Long Island, New York,[2] and Bermuda to Rio de Janeiro, Brazil, including Gulf of Mexico; [9,20] in West Indies, reported only from Cuba.[27]

Area distribution: Chincoteague and Wachapreague on the Virginia seaside; lower parts of Chesapeake Bay, Virginia; [1,18,19,20,21] New Jersey.[25]

Habitat and movements: Adults—a shore species [9] generally found around wrecks or rocky inshore reefs, but preferring areas beneath ledges or around reef caves; also associated with holes and gullies, and sometimes with underwater springs having boils of discolored water; [7,10] enter rivers [3] and creeks; [6,10] found over bottoms of mud, rock, coral, hard sand, and shells; also associated with grass beds, sponges, and gorgonians.[6,8,11,14] Depth 30 [6] to 80 m,[20] but generally 3–7.6 m.[8] Distance out, up to 11.1 kilometers.[25] Recorded salinity range 16.0–37.2 ppt. Temperature 17.8–20.6 C.[24] Appear in shallow water during winter and spring in Florida; [10] otherwise estimates of movements vary from 3.2 km in 6 years [22] to 11 to 88 km in 79 to 1007 days.[23]

Larvae—no information.

Juveniles—over grassy flats [11] and throughout rocky areas offshore; [12] also near river mouths,[16] in harbors,[15] and among gorgonians.[14] Specimens 25 to 49 mm long in shallow grass flats; larger specimens in moderately deep flats along channel edges.[5] Salinity range 15.8 [3] to 37.2 ppt.[24] Recorded temperature range 17.0 [25]–26.7 C.[2] Depth, specimens of 25–186 mm FL from 0.6–11.9 meters. Maximum reported distance out, ca. 4.3 kilometers.[25] Apparently move inshore during first three or four months.[12]

SPAWNING

Season: In Florida main activity probably between January and March.[12]

Fecundity: 655,788 to 1,457,120.[12]

EGGS

Location: Probably pelagic.[12]

Ripe unfertilized eggs: Largest ca. 1.0 mm in diameter (AJM).

Fertilized eggs: Oil globule single.[1]

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

Fig. 38. ***Mycteroperca microlepis***, **Gag. A. Juvenile, 235 mm SL.** *(A, Smith, C. L., 1958: pl. 15.)*

LARVAE

No information.

JUVENILES

Minimum size described, 17.2 mm SL.

At 17.2 mm SL opercular and dorsal spines elongate.[12] At 61.0 mm FL caudal fin rounded.[19]

Pigmentation: At 17.2 mm resembles the adult in pigmentation.[12]

Specimens 61 to 186 mm FL dusky green with iridescent green longitudinal wavy blotches and some individuals with median fins dusky green to black with lighter green blotches.[19]

A 125 mm FL specimen with dorsal fin dark olive; tip of soft dorsal fin blue-black and narrowly edged with white; caudal fin mostly black with hint of blue and with outer edge white; anal fin deep indigo, olive at base, its edge white.[19]

AGE AND SIZE AT MATURITY

Mature as females during 5th and 6th year, transform to males during 10th or 11th year.[3]

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Morone americana
Morone saxatilis
Polyprion americanus

temperate basses
Percichthyidae

FAMILY PERCICHTHYIDAE

The family Percichthyidae, as currently defined (Gosline, 1966), is clearly an artificial assemblage of several unrelated percoid groups. The true affinities of its constituent genera are in need of further study. Percichthyid fishes, of which there are estimated to be about 17 genera and 40 species, occur in marine, brackish, and fresh waters throughout tropical and temperate regions of the world. One of the three regional species, *Morone saxatilis*, is strongly anadromous or potadromous, making extensive spawning runs from the sea into freshwater or from freshwater lakes into rivers. *Morone americana* is more or less restricted to estuarine waters and seldom enters the sea. It is anadromous in some areas, but apparently nonmigratory in others. *Polyprion americanus* is essentially a marine species and only occasionally enters rivers.

The temperate basses usually have two rounded opercular spines (*Niphon* have three), the lateral canals of the head are at least partially enclosed in bone, the maxillary is expanded posteriorly, there are numerous teeth on the jaws, the lateral line is complete and continuous, the caudal fin is usually forked, and there is a minimum of 24 vertebrae.

Protandrous hermaphroditism occurs in the South American genus *Percichthys* and ovotestes have occasionally been observed in the regionally abundant *Morone saxatilis*.

Striped bass frequently spawn in rocky, boulder-strewn areas in moderate to rapid current. "Rock fights" which may be spectacular in their intensity are in fact spawning congresses. During these "fights" one female may be pursued by up to 50 males. One member of the family, *Maccullochella macquariensis*, may bury its eggs, and the eggs may be guarded by the male parent. These observations, however, need to be confirmed.

The eggs of *Polyprion americanus* are pelagic, relatively large (ca. 1.6 mm), and have granular yolk and a number of oil globules, all of which are small but one of which is distinctly larger than the others. *Morone americana* produces small (0.65–1.09 mm) demersal eggs which are attached to the substrate. They typically have one large and several small oil globules. The eggs of *Morone saxatilis* are nonadhesive, buoyant, and highly variable in size (1.65–4.6 mm). There is a single oil globule and a wide pervitelline space. In early stages the yolk is green or golden green.

Early larvae of *Polyprion americanus* have granular yolks, a small posteriorly placed oil globule, and pigment in the dorsal and ventral finfolds. In more advanced larvae and early juveniles the head is proportionately quite large, and there are well-developed spines on the opercle, and distinctive supraorbital serrations. The anus is positioned at a point approximately two-thirds the distance to the tip of the tail.

Larvae of *Morone saxatilis* are quite similar to those of *Morone americana*, and it has thus far been difficult to distinguish between these two species through a size range of 5.0 to 20.0 mm. Dr. Ronald A. Fritzsche and Dr. G. David Johnson, however, have recently discovered differences in bone and cartilage development and internal pigment through this size range. Their work will be published shortly. Early larvae of these two species may be distinguished in the following ways: striped bass (*Morone saxatilis*) are slightly larger than white perch (*Morone americana*) at any given stage of morphological development. In the striped bass the gut angles obliquely downward between the end of the yolk sac and the anus, while in the white perch it follows the line of the body for some distance before angling sharply downward. In striped bass there are three or four myomeres between the end of the yolk sac and the anus, while in the white perch there are usually five or six (this characteristic, however, is not apparent in all of the illustrations presented for these two species). In both species the position of the anus varies from slightly in advance of to slightly beyond the midpoint of the body.

In developing juveniles of the striped bass there is a transitory pattern of dorsolateral bars. This pattern is lost at lengths greater than about 80 mm.

Morone americana (Gmelin), White perch

ADULTS

D.$_1$ VII–XI; D.$_2$ I, 11–13; A. III, 9–10 [7,50] (a count of 12 rays [19] is questioned, JDH); C. 17; [64] P. 10–18; V. I, 5; scales in lateral line 44 [7] to 55,[12,52] in transverse series 20,[31] above lateral line 6–10, below lateral line 9–14, around caudal peduncle 18–24; [7] vertebrae 11 + 14; [23] gill rakers 4 + 13–17,[3,12,50] branchiostegals 7.[6]

Proportions expressed as percent SL: Body depth 28–41 [7] (lacustrine perch may have conspicuously more elongate bodies than estuarine perch [40]), HL 30–39, head depth 20–30.[7] Proportions as percent TL: depth 24.4–29.0, HL 26.3–29.7. Proportions as percent HL: eye diameter 18.9–28.6, snout 28.6–30.9.[60] Proportions as times in HL: interorbital width 4.2–5.2, $\bar{x}$ 4.63; longest dorsal spine ca. 0.5.[46]

Body oblong, ovate, compressed; back moderately elevated; head depressed above eyes; snout pointed; mouth oblique, terminal; lower jaw slightly projected; posterior end of upper jaw beneath front of eye. Teeth small, pointed, and in bands on jaws, vomer, and palatines; [7,12,50] no teeth on base of tongue, but small teeth around distal periphery of tongue.[60] Gill rakers long.[35] Opercle ending in two flat points; preopercular margin serrate. Scales extending onto base of vertical fins and forward on head to nostrils.[50] The two dorsal fins connected, but barely so, and with their base lengths about equal; origin of first dorsal just anterior to midpoint of body; caudal forked.[7,21,50]

Pigmentation: Silvery,[19,20] greenish gray, silvery gray,[12,49] olivaceous,[7] dark green,[46] or nearly black above,[7] sometimes brassy.[14,21] Large individuals with bluish luster on head.[12,50] Sides paler [12] and with silvery [49] or brassy cast [59] and, sometimes, indistinct lateral stripes. Belly silvery white, immaculate.[7,12,19] Underside of mandible bluish purple or pink, particularly during spawning season.[14,41] Melanophores on rays and membranes of all fins; dorsals dusky, but with pigment of second dorsal concentrated on interradial membranes of outer half of fin; [7] anal sometimes rose-colored at base; [32] first and second anal spines darkest basally, spine three and soft rays of anal darkest distally; caudal darkest on posterior 2/3; pectorals essentially colorless; [7] pelvics sometimes plain,[50] sometimes with rose-colored bases.[12]

Maximum length: 495 mm.[1,6,7,9,12,13]

DISTRIBUTION AND ECOLOGY

Range: Coastal areas from New Brunswick, Nova Scotia and Prince Edward Island to Georgetown, South Carolina; [1,6,9,12,21] records from Florida and the Gulf coast are questioned.[7] Introduced into freshwater lakes and ponds in New England,[8] and in Lake Erie and Lake Ontario.[1,5,14]

Area distribution: Coastal waters of New Jersey,[56] Delaware,[11] Maryland and Virginia; [33] found throughout Chesapeake Bay,[50] and the Chesapeake and Delaware Canal.[51]

Habitat and movements: Adults—a schooling species [1,20,23,46] typically found in bays, estuaries, and brackish ponds; but also in unprotected coastal waters,[4,7] freshwater lakes and ponds [21,27] (where it may be permanently landlocked [7,48]), and tidal, murky, detritus-laden creeks and streams.[40] Congregate around piers, timbers, and bridges, and among water lilies. In southern parts of range (for example, in North Carolina) apparently restricted to the estuarine environment.[52] Prefer level firm bottom of silt, mud, sand, or clay [20,23,28,40,41] having little cover. Rarely over rubble bottom with extensive cover (growth is apparently stunted in this environment).[21] Usually at 4.6 to 9.1 m during daylight hours and at 0.9 to 1.2 m at night during summer; 12.2 to 18.3 m in winter.[23,46] Occasionally in schools at surface.[9] Maximum depth, 42.1 m. Recorded offshore at Block Island, Rhode Island, a distance of approximately 16.1 km.[50] Reported from temperatures of 2.0 to 32.5 C,[48] but optimum varies from population to population. Found in Maine lakes where summer temperature is seldom above 15.5 C and in Massachusetts lakes where summer temperature is seldom below ca. 27 C.[46] In other populations mortality may occur if temperature stays close to ca. 27 C for several days.[23] Reported from pH range 6–9.[46] Usually in salinity range 5 to 18 ppt,[54] but also in freshwater (particularly in northern part of range),[23] and in salinities of at least 30 ppt.[48]

Anadromous or semi-anadromous in some areas, but not in others.[6,41,50] Marine or estuarine populations move shoreward and generally upstream in spring, sometimes in large schools, to the shore zone (arriving by early April), tidal creeks, or freshwater areas.[7,21,40,47,48,55] In Patuxent River may move up to 96.6 km during spawning run.[38] Summer movements are thought to be local and random,[13] although some populations may move into deeper water immediately after spawning,[12] and, in Nova Scotia, there is an extensive seaward migration in summer.[2] Overwinter in deep waters of bays.[12,44,47,48] Adults generally more inshore at night or when water is rough or turbid.[9,46] Specimens marked in Chesapeake Bay tributaries were not recaptured in the bay proper, suggesting that the various regional populations may be restricted to specific tributaries.[39]

Larvae—yolk-sac larvae settle to bottom [6,42] where they

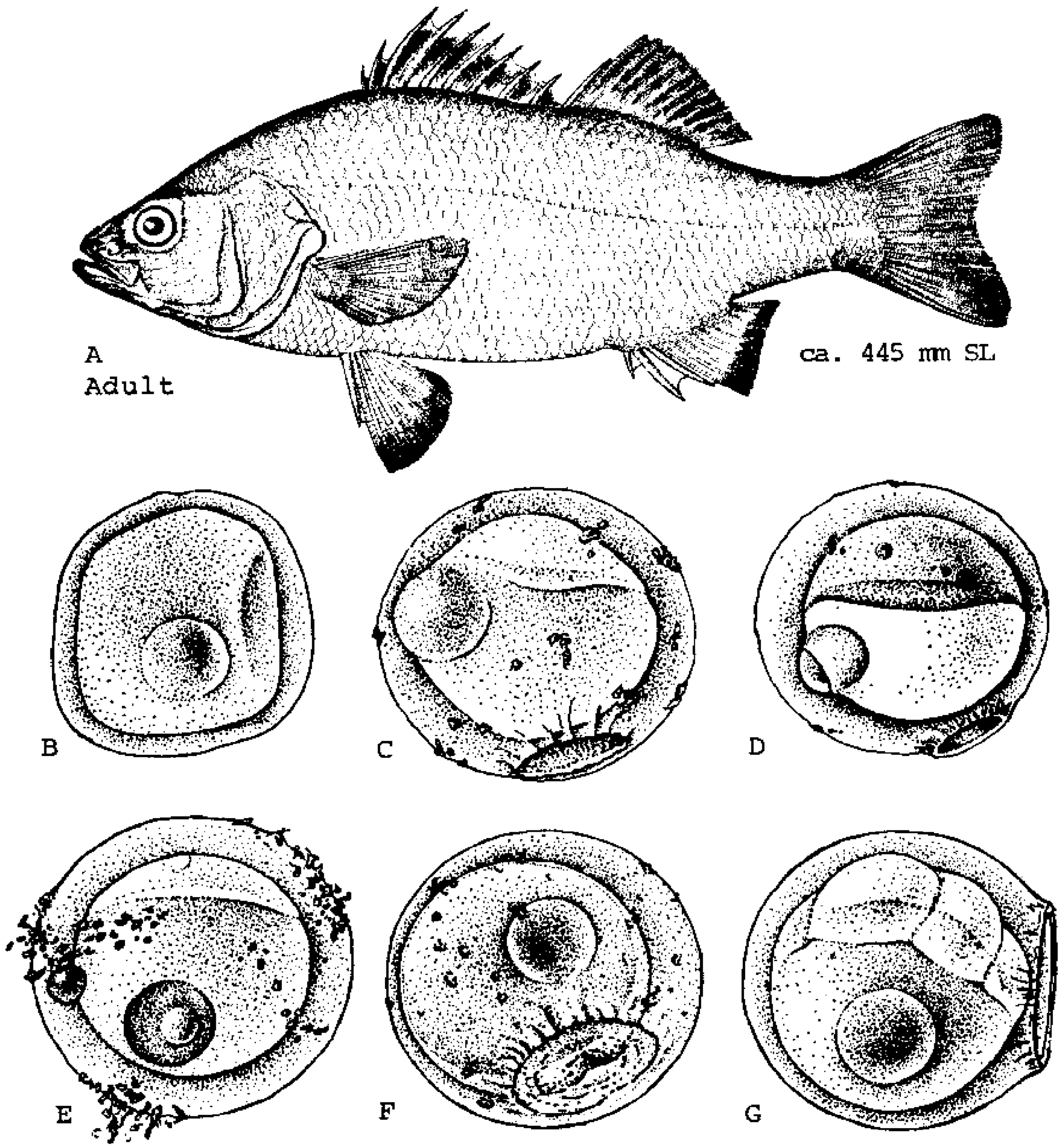

Fig. 39. *Morone americana,* White perch. A. Adult, ca. 445 mm SL. B. Unfertilized egg. C. Recently fertilized egg, blastodisc formed. D. Maximum development of blastodisc. E. Recently fertilized egg, blastodisc formed, 2 oil globules present. F. 2-cell stage (blastomeres visible through attachment disc). G. 5-cell stage (irregular cleavage). (*A-G, Mansueti, R. J., 1964: fig. 3.*)

may lie on their sides; [15] occasionally swim to surface (assuming head up position) or attach to floating debris; phototropic and heliotropic.[6] Specimens 8 to 13 mm over mud bottom; [9] also recorded at ca. 12 mm or less along shore zone in quiet water,[21] and, at ca. 12 mm, on current swept sand and gravel bars.[22] The nursery area for larvae is apparently the same as the spawning area.[42] Maximum depth for larvae 8 to 13 mm long, 2.4 to 3.6 m.[9]

Freshwater to at least 8 ppt; [6] although experimental limit is 8 ppt, young (which may have included juveniles) have been collected at 13 ppt; [32] usually at less than 1.5 ppt.[42]

As development proceeds there is a general downstream movement of the larvae.[42]

Juveniles—young generally along shoreline in shallow, sluggish water over silt or mud bottom, sometimes among plants; also in channels; sometimes in large schools.[7,21,28,46,48] Remain in nursery area to at least 20 to 30 mm,[42] or, to an age of one year.[32] Specimens less than 25 mm along beaches; also observed, under aquarium conditions, to forage on bottom and hide among aquatic vegetation.[6] At 25 to 75 mm along sandy shoals and beaches, particularly at evening.[17,23,24] Maximum depth, unknown, but recorded from unspecified depth in water 2.4 to 3.6 m deep. Salinity, mostly at less than 3 ppt, also up to 7 ppt,[42] and possibly to 13 ppt.[32]

In estuarine populations remain in schools during summer months, move toward brackish water between August and late November and separate.[29,32,47] At ca. 20 to 25 mm begin moving inshore in evening to shoal and beach areas [6,9,21,23] retaining this habit to at least 75 mm; [17,24] also move inshore when water is rough and turbid.[46]

SPAWNING

Location: Estuarine populations in fresh,[21,50] tidal fresh or slightly brackish water [6] (a report of spawning in the ocean [1] is questioned, JDH) mostly in lower reaches of large coastal rivers [7] on sand and gravel bars; also ripe adults on rocky ledges.[9] Spawning assemblies may include hundreds of ripe fish,[50] and such assemblies may be particularly common in freshwater spillpools of larger creeks.[48] Raney felt that actual spawning may take place at the surface [21] while Mansueti presumed that it occurred under banks of streams or sunken trees or debris.[13] Spawning also occurs in shoal or shore areas in freshwater ponds and lakes; also in tributary streams and shallow coves where large aggregations may form.[6,12,16,27,46]

Bottom: Mostly over fine gravel or sand; also over pulverized snail shell; in some areas over predominantly clay bottom.[9,12,46]

Season: Over entire range, late March [18,22,52] to late July.[6] In North Carolina ripe of both sexes March 22 to April 19 [52] (although some North Carolina workers have estimated a total spawning period of only 10 days [31,50]); in Chesapeake Bay (Virginia and Maryland) late March [13,32] to early June,[6] but, in some years, eggs not evident in upper bay until early April.[1,27,37,42,54] Winter spawning in lower Chesapeake Bay has been suggested,[1] but there are no records of eggs being deposited before March (JDH). Hildebrand and Schroeder [50] reported ripe specimens of both sexes in mid-December, while de Sylva, Kalber, and Shuster [57] observed the same situation in mid-November. Mansueti questioned the ripeness of winter eggs.[6,13] In Delaware mostly in May,[40] but also reported from early April [48] to early June; [29,40] in New York, April and May; [44] in Rhode Island, April, May, and June; [10] in Connecticut, April and May; [9] at Woods Hole, Massachusetts, May and June; [4,44] in Lake Ontario mid-May to end of June; [65] in Maine late May [32,36] to July.[9,35] There is a difference in spawning season between freshwater and marine populations with marine populations spawning generally in April and May and freshwater populations in May, June, and July.[21,36,55]

Period: All eggs are not released at once [6,40] and ovulation may continue over a period of 10 to 21 days.[6,12,17,23,25]

Time: Possibly at dusk, also during daylight hours.[13,21]

Depth: Ripe individuals recorded at 0.9 to 6.1 m; [9,50] also spawn in lakes having maximum depth of 1.5 m.[12,46] A record of ripe males and females at 38 m is based on specimens secured in December in Chesapeake Bay [50] and has been questioned.[6,13]

Temperature: 10 [6,13] to 19 C,[48] average (based on Delaware data) ca. 15–16 C.[40] In York River, Virginia, peak activity at 11–16 C.[42] In Ontario at 11–15 C.[65] In North Carolina spawning may begin when temperature is near 12.5 C,[19] but in Maine temperature may remain at 18–21 C for several days prior to actual spawning.[23]

Salinity: Maximum salinity, 4.2 ppt [18] (a report of spawning in oceanic water [1] is questioned, JDH).

Fecundity: 5210 to 321,000.[28,41] Brice stated an average of 40,000,[24] and this figure has been repeated by numerous authors.[1,12,23,34,46] Regional estimates are: North Carolina 20,304 to 90,167; [52] Chesapeake Bay 50,000 to 150,000; [13] Delaware (reported maximum) 280,000.[40] Various estimates related to size and age: an 0.5 kg fish estimated to produce 160,000 (including thousands of immature eggs); [23] an age III fish 224 mm long, 90,167; age group III and IV fish 190,000 to 321,000 ($\bar{x}=271,000$).[61] Estimated eggs per kg of fish, 56,188.[23] In Ontario Sheri and Power noted three size groups of ovarian eggs,[61] while in North Carolina Conover noted only two size groups.[52] Mansueti suggested that fecundity increases with female size.[6]

EGGS

Location: Demersal.[6] Typically attached to grass, rocks, and debris,[10,17,25] usually singly,[6] sometimes in small clumps or thin layers.[22,23,45] May also float free [6] and be carried away from point of deposition.[32] Sometimes deposited over clear sandy river bottoms.[19] Under laboratory conditions eggs may be stripped onto cotton yarn and transfered under damp cloth.[30]

Ovarian eggs: At 0.16 mm with single homogeneous membrane, at 0.28 mm zona radiata two-layered, at 0.40 mm total thickness of membrane more than doubled.[8] At least two distinctly different size groups of eggs in all parts of ovary.[41] Maturing eggs, 0.65–0.75 mm in diameter, yellowish, granular, and partly translucent.[18]

Unfertilized eggs: Amber colored and of "apple-sauce consistency," [6] variously reported as 0.58 to 0.80, mean 0.715 mm, 0.70 to 0.89, mean 0.79 mm, and 0.30 to 0.84, mean 0.63.[41]

Nonwater-hardened eggs: Irregular in shape and chorion covered with thick layer of adhesive material.[6]

Fertilized eggs: Spherical, except for attachment disc [6,25,5?] which forms by flow of adhesive material to point of

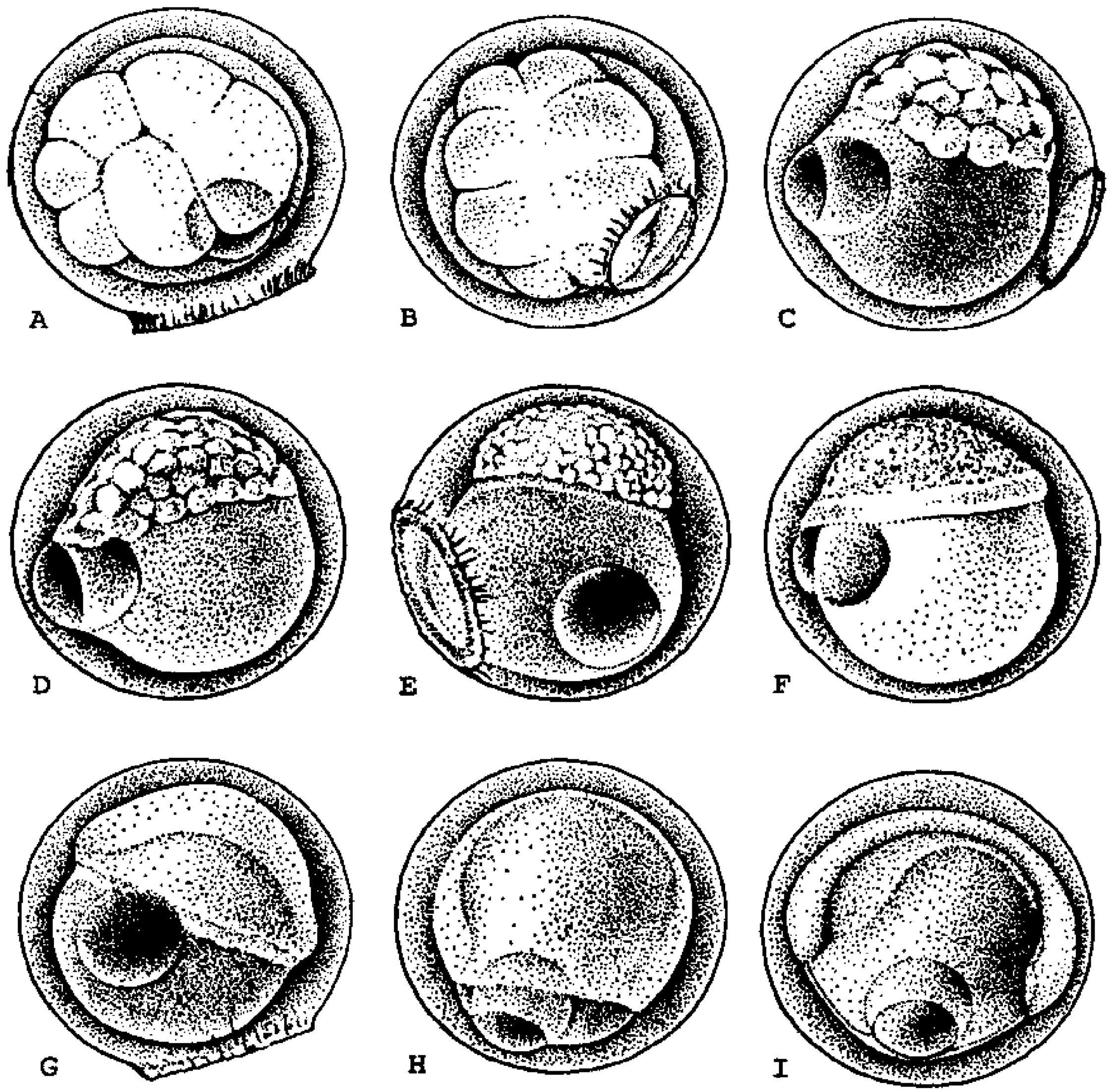

Fig. 40. *Morone americana*, White perch. A. 6-cell stage (note irregular and incomplete cleavage). B. 8-cell stage. C. Ca. 32-cell stage. D. Ca. 64-cell stage. E. Early morula. F. Early formation of germ ring. G. Early gastrula, blastoderm at equator of egg. H. Late gastrula. I. Embryo well formed, blastopore closed. *(A-I, Mansueti, R. J., 1964: figs. 3–4.)*

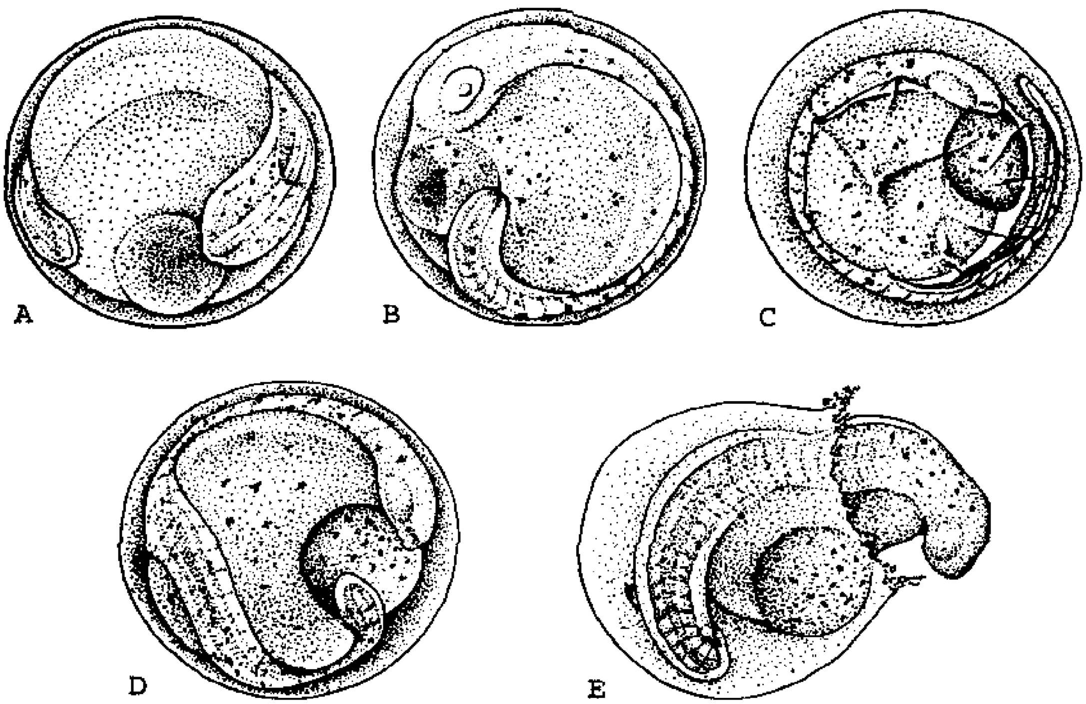

Fig. 41. *Morone americana,* White perch. A. Pigment on body and oil globule. B. Ca. 25 somites, pigment developed on trunk, tail, yolk sac, and oil globule. C. Advanced embryo, tail free. D. Advanced, tail-free embryo, ca. 48 hours old. E. Hatching stage, 50 hours after fertilization. *(A-E, Mansueti, R. J., 1964: fig. 4.)*

contact with foreign body or other eggs; [45] diameter 0.65 to 1.09 mm; [6] zona radiata thin, two-layered, and traversed by fine pore canals; [8,45] chorion thick, tough, turgid, rough surfaced, yellowish brown to brownish gray, rarely transparent, frequently translucent, occasionally opaque; [6] *diameter of micropyle, 0.0075 mm;* [18] initially adhesive,[1,6] and with great variation in attachment rate of detritus or substrata to eggs during different developmental stages.[32] Yolk amber colored or whitish yellow in preserved eggs, lightly granulated, diameter 0.50 to 0.89 mm, mean 0.70 mm. Usually a single large amber oil globule, sometimes several to many smaller ones, diameter 0.20 to 0.44, mean 0.32 mm. Perivitelline space narrow, ca. 24% egg diameter.[6,53]

EGG DEVELOPMENT

Development at *ca. 18.3 C (Mansueti series):* [6]

Ca. 10 minutes	Perivitelline space begins to develop.
Ca. 20 minutes	Mostly 1- and 2-cell stages.
Ca. 45 minutes	Mostly 2- and 4-cell stages, some approaching 8-cell.
1 hour	4-, 8-, and 16-cell stages, perivitelline space fully formed.
2 hours	Few 4-cell, many 8-cell and 16-cell, and some approaching 32-cell stage.
3 hours	16- to 64-cell stages, with 32-cell stage predominating; blastoderm berry-like in advanced stages.
6 hours	Morula stages predominate, blastoderm granular.
10 hours	Blastoderm growing down over 1/2 yolk and characterized by great thickness and swollen rim.
14 hours	Blastocoel formed, periblast thickened, yolk more or less constricted, blastopore closed, few eggs with primitive streak.
18 hours	Embryo developed around more than 3/4 yolk circumference, neural ridge visible.
24 hours	Embryo pigmented, somites barely evident on tail, movement established in tail.
30 hours	Oil globule and yolk sac pigmented, eye well formed, tail free.
36 hours	Tail noticeably longer, oil globule and yolk sac more prominently pigmented with stellate chromatophores.
44 hours	Embryo ready to hatch, ca. 25 somites formed.

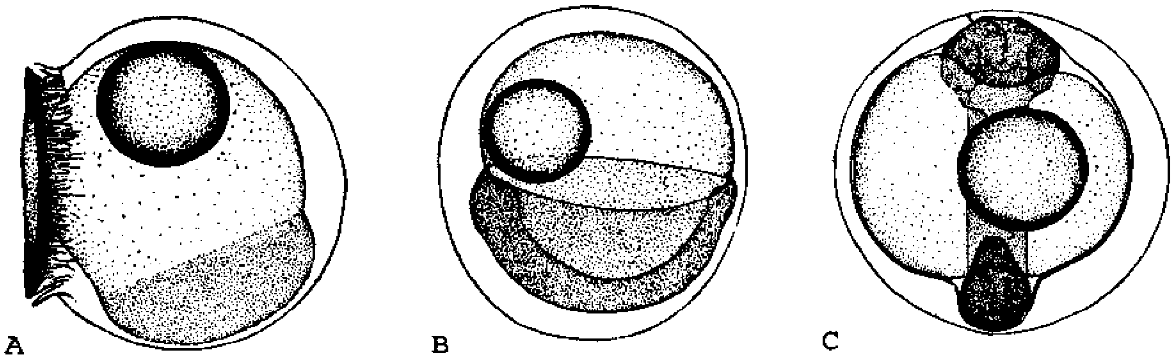

Fig. 42. *Morone americana*, White perch. A. Recently fertilized egg showing large oil globule and attachment disc, well-developed blastodisc. B. Blastoderm over one-third of yolk, head differentiated. C. Early embryo, tail attached, optic vesicles differentiated. (*A-C, Ryder, J. A., 1887: pl. 8.*)

44–50 hours   Hatching.[6]

In a separate paper Mansueti and Mansueti stated that, at 18.3 C water hardening occurred in 15–20 minutes, the 2-cell stage occurred in ca. 1 hour, pigment developed on the body at ca. 33 hours, and the eyes were clearly outlined at ca. 38 hours.[15]

Ryder working at 10.6 to 11.7 C, pointed out that Kupffer's vesicle was formed prior to the tail-free stage when the embryo was more than halfway around the circumference of the yolk.[45]

Incubation period:

At 7.2 C	Little development.[12]
At 8.9–20.0 C	51 to 58 hours.[41]
At 10.6–11.7 C	6 days.[10,23,45]
At 11.1 C	Ca. 6 days.[22,52]
At 11.1–21.7 C	70 to 73 hours.[41]
At 14.4 C	Ca. 3 [44]–4 1/2 days.[12,23,46,58]
At 14.4–15.6 C	6 days.[30,36]
At 15.6 C	24 to 30 hours.[23,55]
	48 to 52 hours.[46,59]
	72 hours.[1]
At 17.2 C	Ca. 48 hours.[21]
At 18.3 C	44 to 50 hours.[21]
At 18.3 C (but with transport temp. 12.8–17.8 C)	44 to 54 hours.[6]
At 20.0 C	24 [62]–ca. 30 hours.[12,46]
At 21.1–25.0 C	34 to 42 hours.[41]

About 7.2 C is minimum temperature tolerance [41] and at 10.0 C or lower few eggs survive.[23] A sudden drop of 2.2 to 2.8 degrees C may destroy the eggs.[16,23,42]

YOLK-SAC LARVAE

Hatching length 1.7 to 3.0, mean ca. 2.6 mm. Maximum length at end of stage 3.9 mm.[6] Duration of stage 4 [55] to 13 days.[15]

Total myomeres 21 to 26; preanal myomeres 11 to 14, mean 12 (and somewhat higher at hatching than at later stage); postanal myomeres 10 to 12, mean 11.[6]

Vent at ca. 2/3 length of body. HL ca. 8% TL.[6]

Body tadpole-like at hatching, straightened at 2.8 to 3.0 mm. Head initially deflected downward over yolk, straightened at ca. 3.0 mm. Cranium poorly developed at hatching. Yolk sac at hatching not projected beyond head (as in *Morone saxatilis*), at ca. 2.8 to 3.5 mm ovate to rectangular. Oil globule prominent, anterior. Mouth not formed at hatching, first evident as a depression on ventral part of head. Teeth lacking throughout larval stage.[6] Otoliths clearly evident by ca. 3.0 mm.[45] Finfold forward to head throughout most of stage, at 2.8 to 3.0 mm characteristically elevated mid-dorsally and postanally. Pectoral buds lacking at hatching, first evident as low horizontal folds at ca. 3.0 to 3.5 mm,[6] or at age of 5 days.[45] Actinotrichia of caudal fin evident at ca. 3.9 mm. Intestine posterior to yolk parallel to body axis until it angles downward to anus. Liver evident as bud-like outgrowth from ventral wall of mesenteron at ca. 3.0 to 3.5 mm.[6]

Pigmentation: At hatching body virtually without pigment. At ca. 2.8 to 3.0 mm (ca. 1 day) pigment developed on body, yolk sac, oil globule, and ventral edges of hindgut and trunk. At ca. 3.0 to 3.5 mm (ca. 2 days) pigment developed on head, anterior region of oil globule, posterior part of yolk sac, ventral edges of hindgut and trunk, and sparsely on dorsal edge of trunk. Live larvae of these sizes are transparent with orange and brown chromatophores except on oil globule on which dark melanophores are concentrated. Orange chromatophores concentrated about one-third distance from tip of caudal fin.[6]

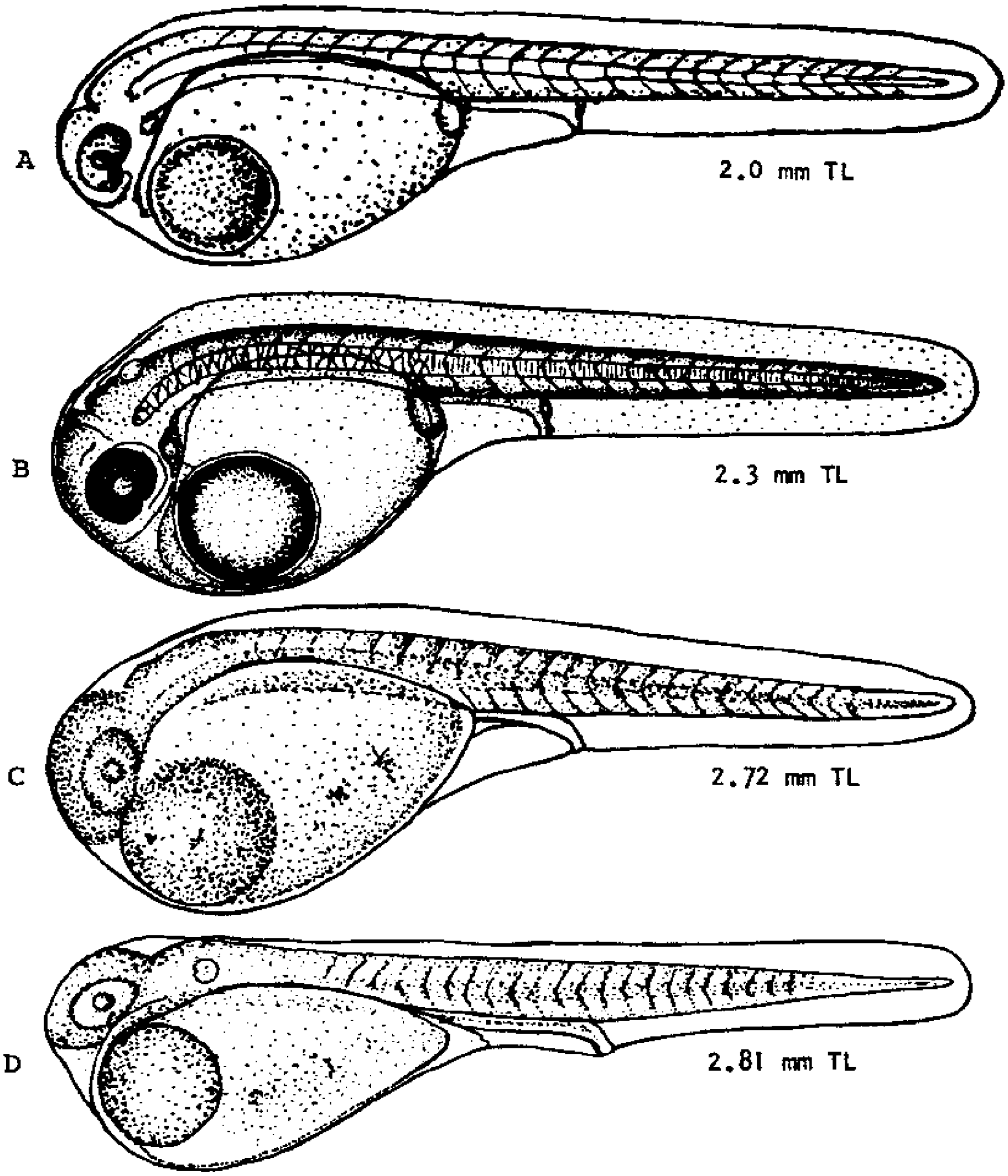

Fig. 43. ***Morone americana***, White perch. A. Yolk-sac larva, 2.0 mm TL. B. Yolk-sac larva, 2.3 mm TL. C. Yolk-sac larva, 2.72 mm TL. D. Yolk-sac larva, 2.81 mm TL. (*A, Mansueti, R. J., and A. J. Mansueti, 1955: 1. B, Ryder, J. A., 1887: fig. 40. C, D, Mansueti, R. J., 1964: fig. 6.*)

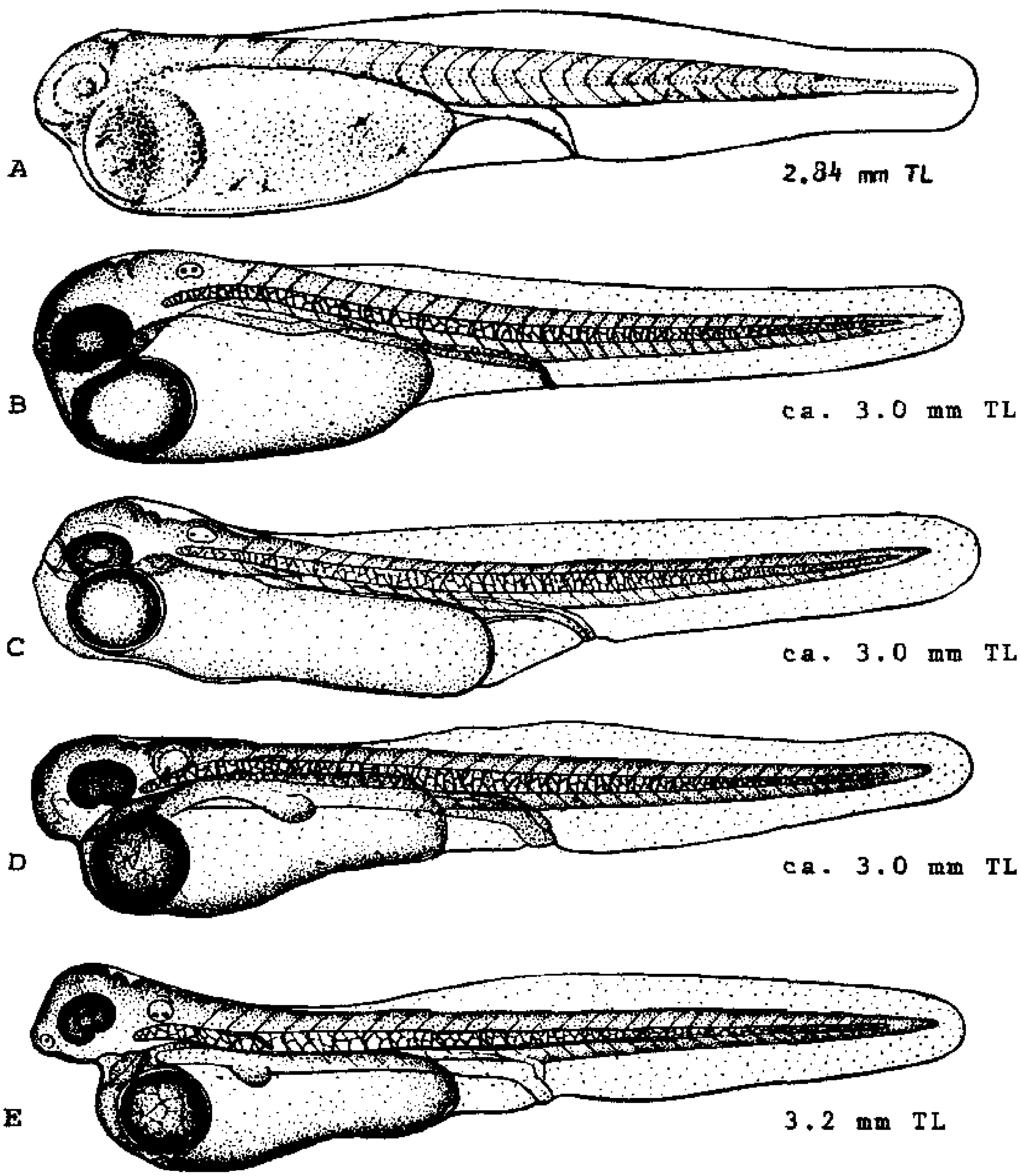

Fig. 44. *Morone americana*, White perch. A. Yolk-sac larva, 2.84 mm TL. B. Yolk-sac larva, ca. 3.0 mm TL. C. Yolk-sac larva, ca. 3.0 mm TL. D. Yolk-sac larva, ca. 3.0 mm TL. E. Yolk-sac larva, 3.2 mm TL. (*A, Mansueti, R. J., 1964: fig. 6. B-E, Ryder, J. A., 1887: figs. 41–44.*)

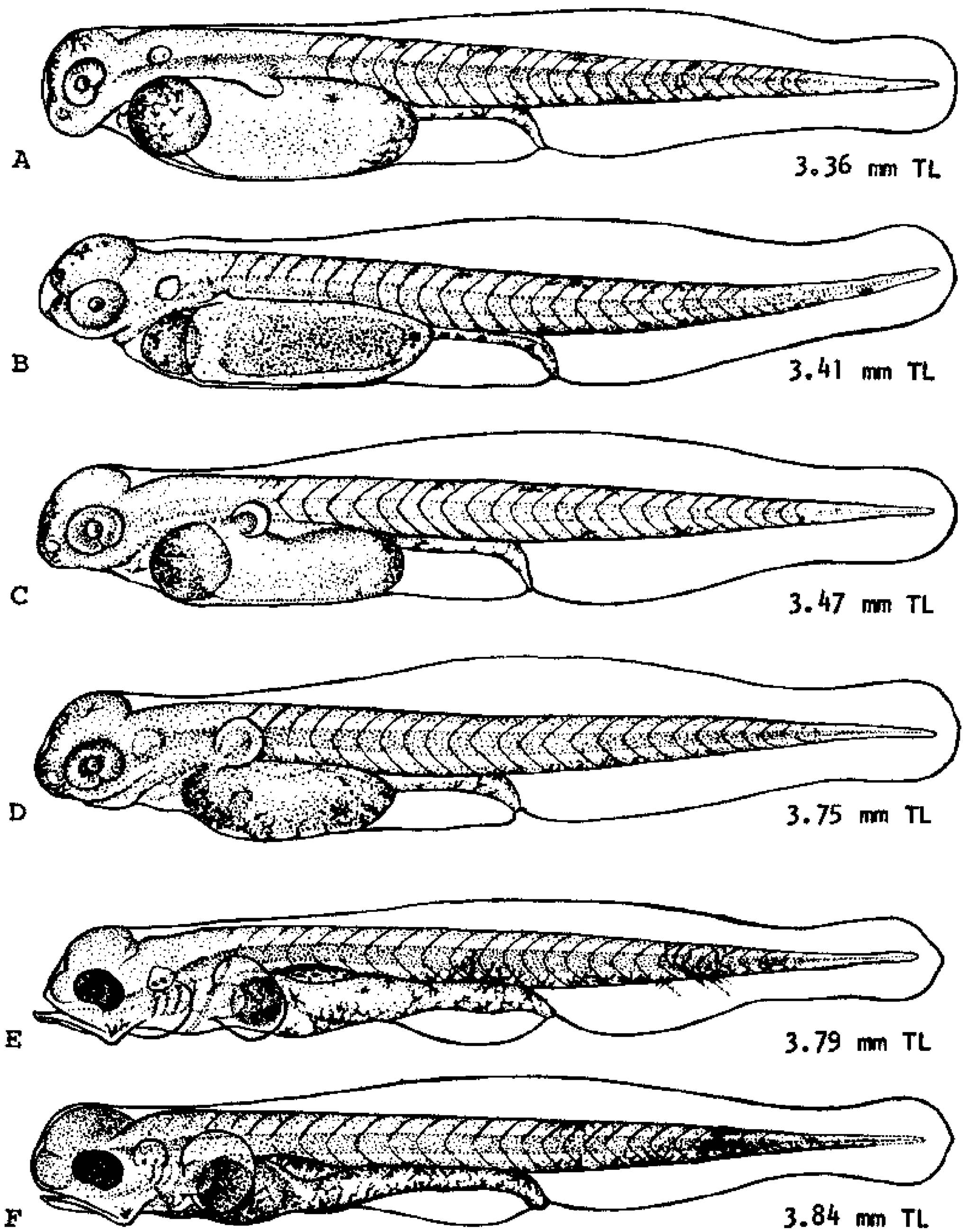

Fig. 45. *Morone americana*, White perch. A. Yolk-sac larva, 3.36 mm TL. B. Yolk-sac larva, 3.41 mm TL. C. Yolk-sac larva, 3.47 mm TL. D. Larva, 3.75 mm TL. E. Larva, 3.79 mm, gas bladder forming. F. Larva, 3.84 mm. (*A-F, Mansueti, R. J., 1964: figs. 6–7.*)

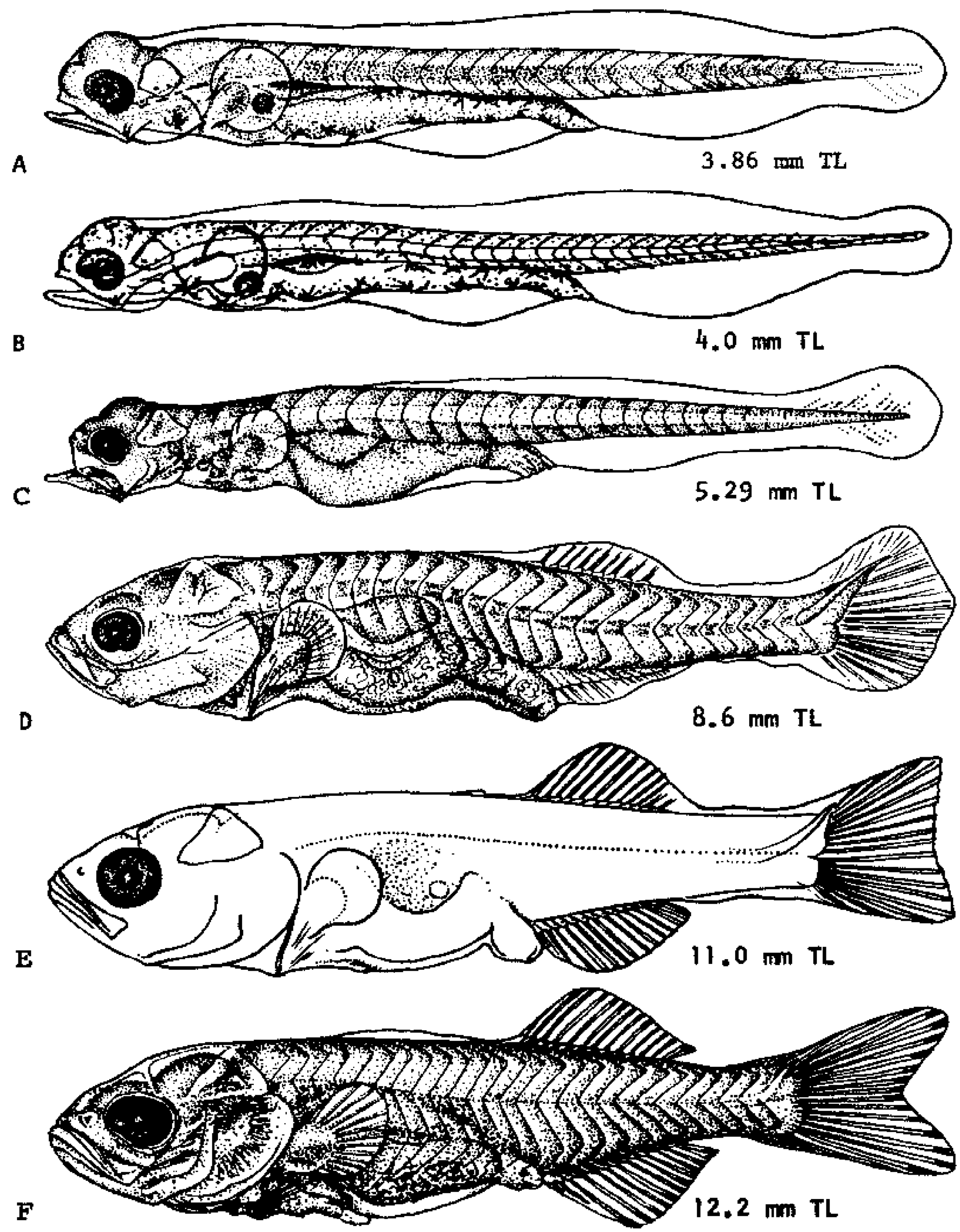

Fig. 46. *Morone americana*, White perch. A. Larva, 3.86 mm TL. B. Larva, 4.0 mm TL. C. Larva, 5.29 mm TL. D. Larva, 8.6 mm TL. E. Larva, 11.0 mm TL, pelvic buds evident. F. Larva, 12.2 mm TL. (*A, C-F, Mansueti, R. J., 1964: figs. 7, 10. B, Mansueti, R. J., and A. J. Mansueti, 1955: 1.*)

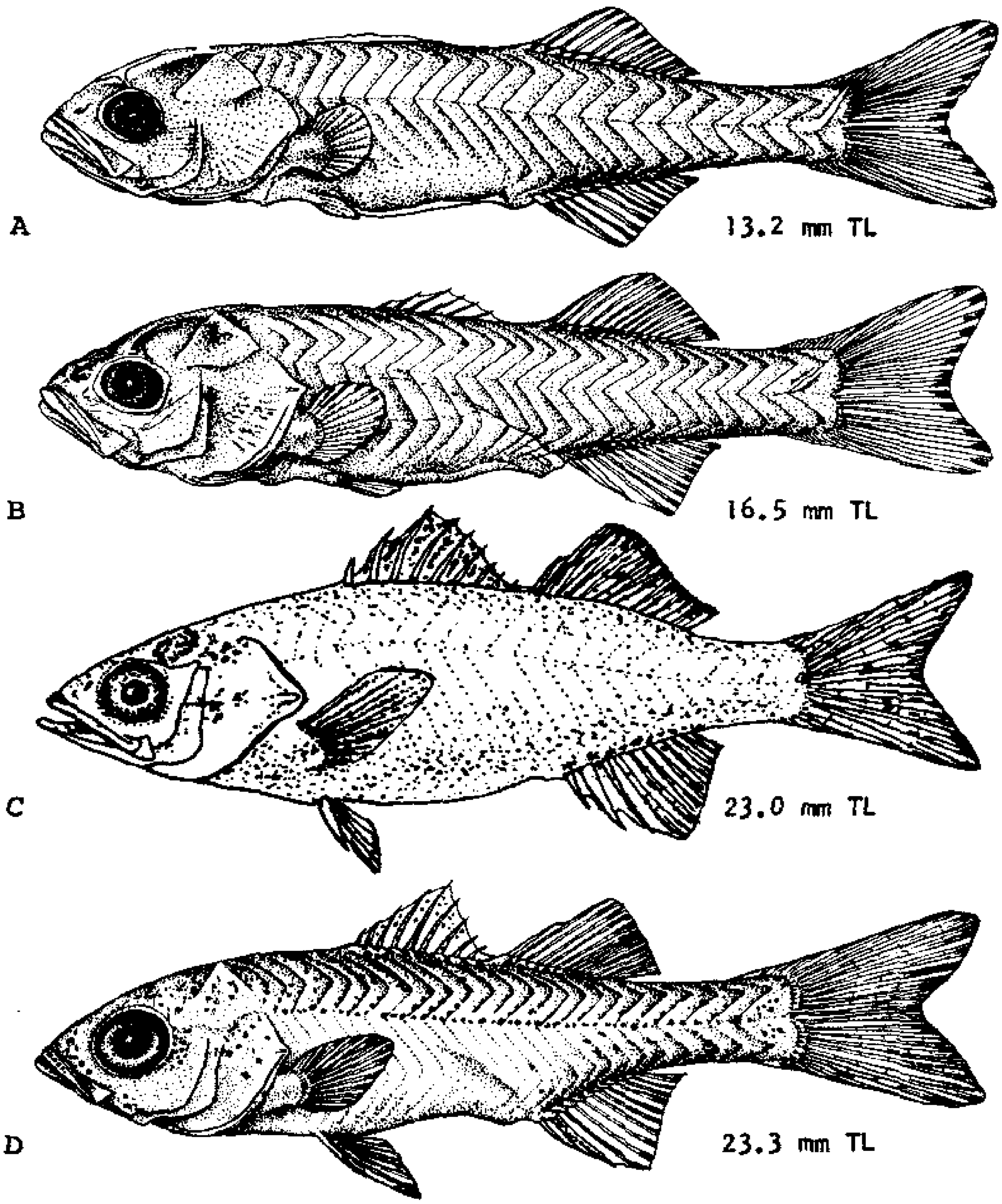

Fig. 47. *Morone americana*, White perch. A. Larva, 13.2 mm TL. B. Larva, 16.5 mm TL, pelvics and first dorsal fin incomplete. C. Juvenile, 23.0 mm TL, pigment developing in fins. D. Juvenile, 23.3 mm TL. (*A, B, D, Mansueti, R. J., 1964: figs. 10, 11. C, Mansueti, R. J., and A. J. Mansueti, 1955: 1.*)

LARVAE

Size range described, 3.4 *to 19.0 mm (although full complement of pectoral and anal rays may not be evident until ca. 30 mm).*

Total myomeres 23 to 26; preanal myomeres 11 to 13; postanal myomeres 12 to 13; vertebrae 12+13; vertebrae first evident at ca. 8.0 mm.[8]

Caudal peduncle relatively deep; trunk thick, deep; head relatively short; anus ca. 55 percent of distance back along body. Branchiostegal rays first evident at ca. 10 mm, full complement at ca. 15 mm. Opercular spines evident in some specimens at ca. 14 mm, preopercular serrations at 25 to 30 mm. Mouth well formed at 3.84 mm; teeth evident in both jaws at 15 mm and over; choroid fissure evident until ca. 3.7 mm. Gill arches and

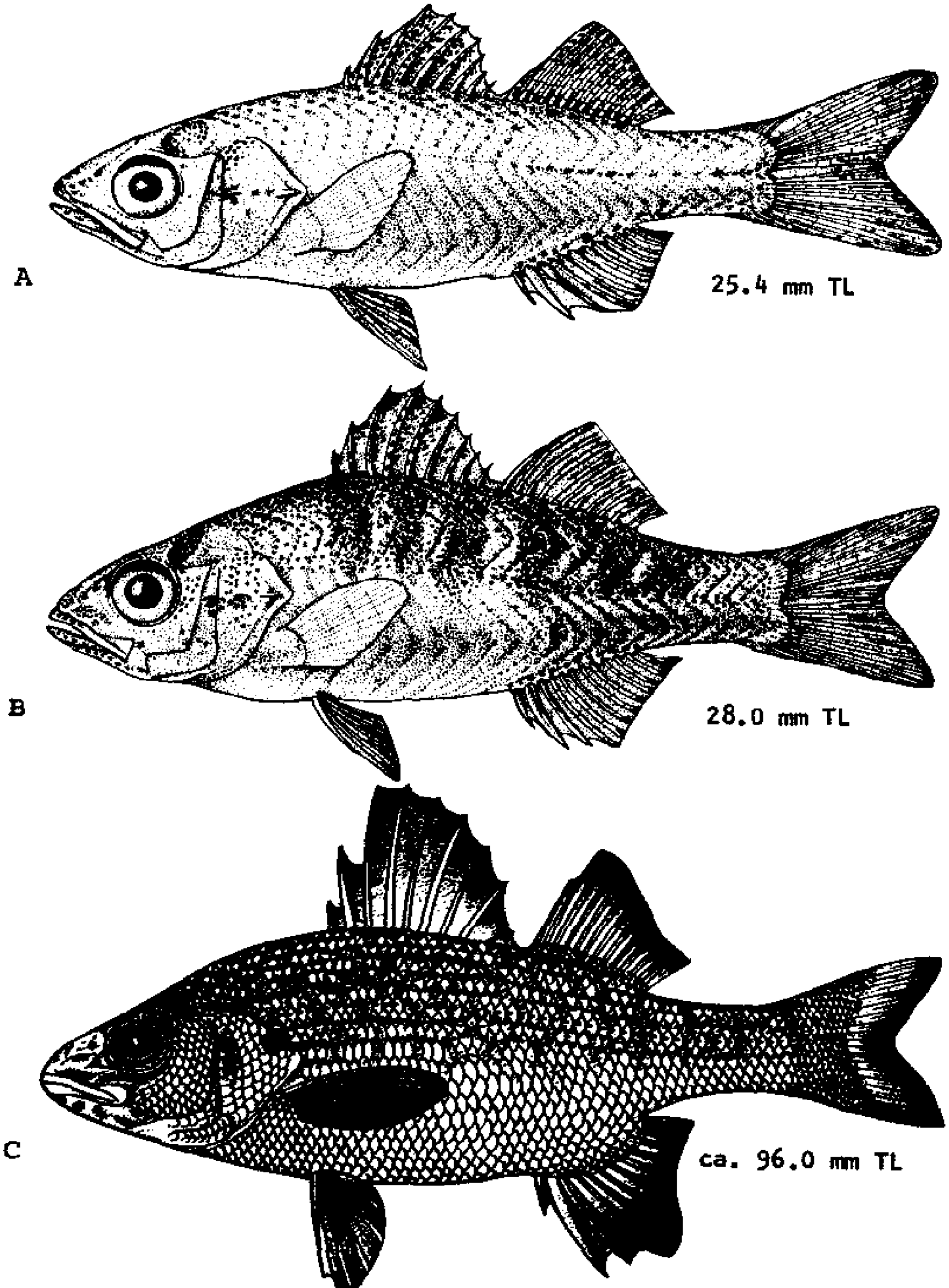

Fig. 48. *Morone americana*, White perch. A. Juvenile, 25.4 mm TL. B. Juvenile, 28.0 mm TL. C. Juvenile or young adult, ca. 96.0 mm TL. (*A, B, Mansueti, R. J., 1964: fig. 11. C, Fowler, H. W., 1945: fig. 261.*)

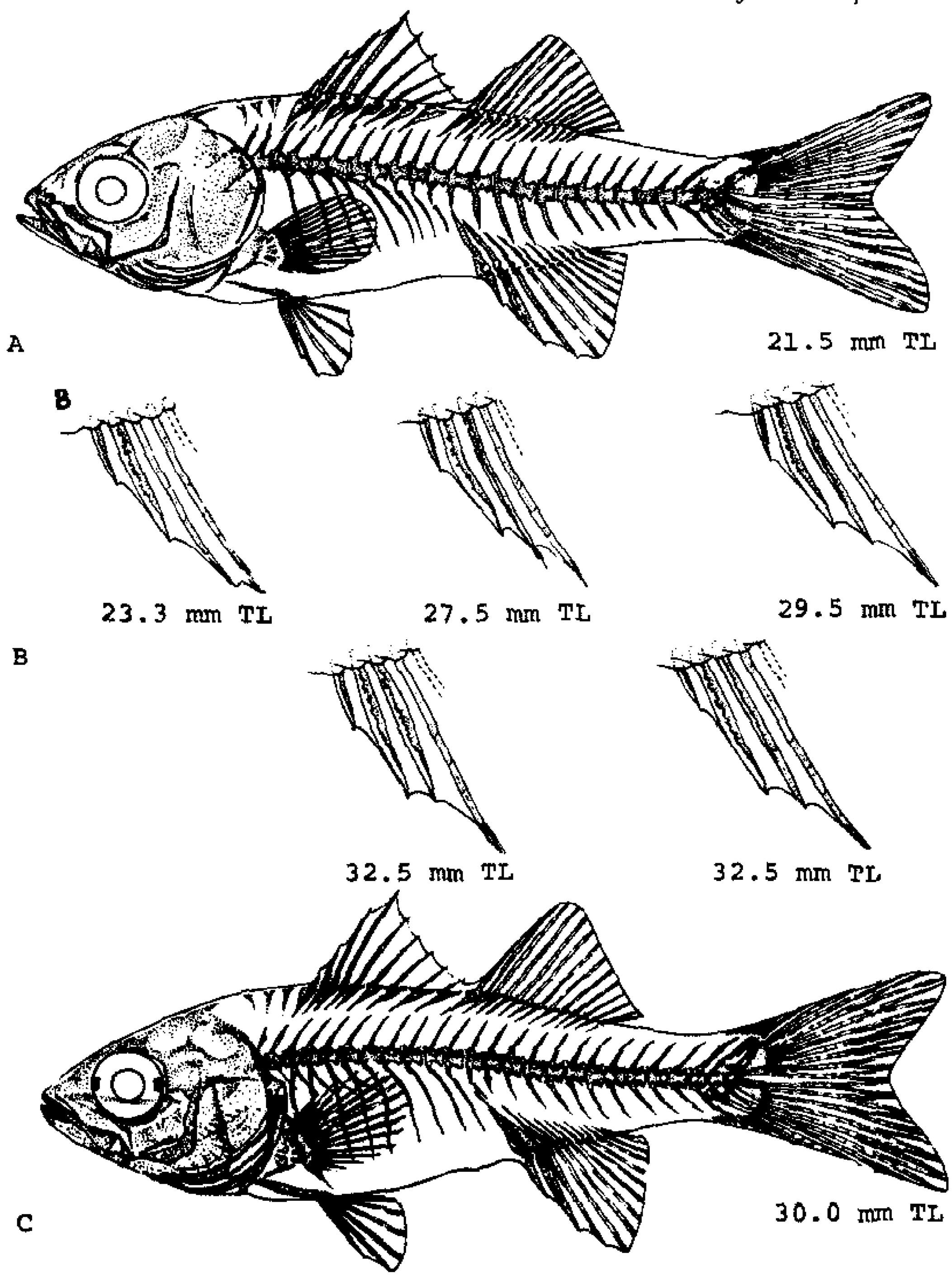

Fig. 49. *Morone americana*, White perch. A. Recently metamorphosed young, 21.5 mm TL, incomplete cephalic ossification. B. Formation of third anal spine from a soft ray through a size range of 23.3 to 32.5 mm TL. C. Juvenile, 30.0 mm TL, skeleton essentially adult-like. (*A-C, Mansueti, R. J., 1964: fig. 12.*)

cleithrum formed at 3.5 to 4.0 mm. Scales evident in some specimens at 19 mm, but not evident in ca. one-half specimens 19 to 25 mm long. Urostyle oblique at 7.0 to 9.0 mm. Gas bladder formed at ca. 3.5 to 4.0 mm. Dorsal finfold noticeably reduced at 5.29 mm. Soft dorsal rays evident at ca. 8.0 mm, full complement at ca. 17.0 mm. Fold connecting two dorsal fins not evident until ca. 12 mm, well differentiated at ca. 20 mm. Lepidotrichia of anal at ca. 8.0 mm, all spines and rays not fully formed until ca. 30 mm. Incipient caudal rays first evident at 3.86 mm, countable lepidotrichia at ca. 10.0 mm, caudal fin essentially homocercal at 11.0 mm. Pectoral actinotrichia evident at ca. 10 mm, lepdidotrichia not countable until ca. 30 mm. Pelvic buds first evident at 11.0 mm, full complement of spines and rays at ca. 13.0 mm.[6]

Pigmentation: At 3.5 to 4.0 mm eye pigmented, golden orange in life; pigment previously noted on head now absent. At 12.0 to 14.0 mm, pigmentation very sparse. Early larvae with orange and brown chromatophores on ventral edge of trunk and remnant of oil globule; few chromatophores on dorsal edge of trunk. In advanced but still transparent larvae orange and brown chromatophores on gut and few chromatophores on ventral edge of posterior trunk.[6]

JUVENILES

Minimum size described, ca. 30.0 mm.

Anus at point ca. 52 percent of TL throughout stage. At 20 to 25 mm body relatively slender; head length ca. 27 percent of TL at 22.0 to 39.0 mm. Body depth adult-like at 25.0 mm.[6]

Skull and hypural complex incompletely ossified at 20.0 to 25.0 mm.[6]

Pigmentation: At ca. 20.0 mm small chromatophores profusely scattered on snout, head, operculum, dorsolateral part of body, and entire posterior part of trunk; also on spinous and soft dorsal, anal, and caudal, and along lateral line. At ca. 25.0 to 75.0 mm, 5 to 7 dusky vertical bars on sides, and, occasionally, faint horizontal stripes.[6,9,21,41] Young less than ca. 100 to 125 mm long usually silvery gray, never with blue on head.[50] Young-of-the-year with dark brown horizontal stripes on sides, lost by age group I.[41]

AGE AND SIZE AT MATURITY

All males and some females mature at 2 years; many females at three; all mature at four[21] (see also references [12,13,19,23,40,43,61]). Males mature by 72.0 mm, females 98.0 mm[40] (see also references [6,13,27,43,50,61]).

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Morone saxatilis (Walbaum), Striped bass

ADULTS

D. $_1$ VIII–IX [22,156] (a count of XI [98] is questioned, JDH); D. $_2$ I,[45] 9–14 [39,45,93,94,136] (in Chesapeake Bay D. $_1$ IX,[152] D. $_2$ soft rays 10–14 [3,39,45,93,94,136]); mode D. $_2$ rays, 11 in Hudson River, 12 elsewhere; [195] A. III [95,156] (a count of IV [219] has been questioned [70]) 7–13 (in Chesapeake Bay 9–12 [3,22,39,94,119,136]); mode number anal rays 11; C. 17, 15 branched; [70] P. 13–19 (including Chesapeake Bay); [119] V. I, 5; [7] lateral line scales 50 [66]–72, but in rivers of western Florida and Alabama 63–72,[147] all other populations combined 50 [66]–67 [147] (Chesapeake Bay 53 [119]–65 [3,109]); scales above lateral line at mid-body 9–13, below 13–16;

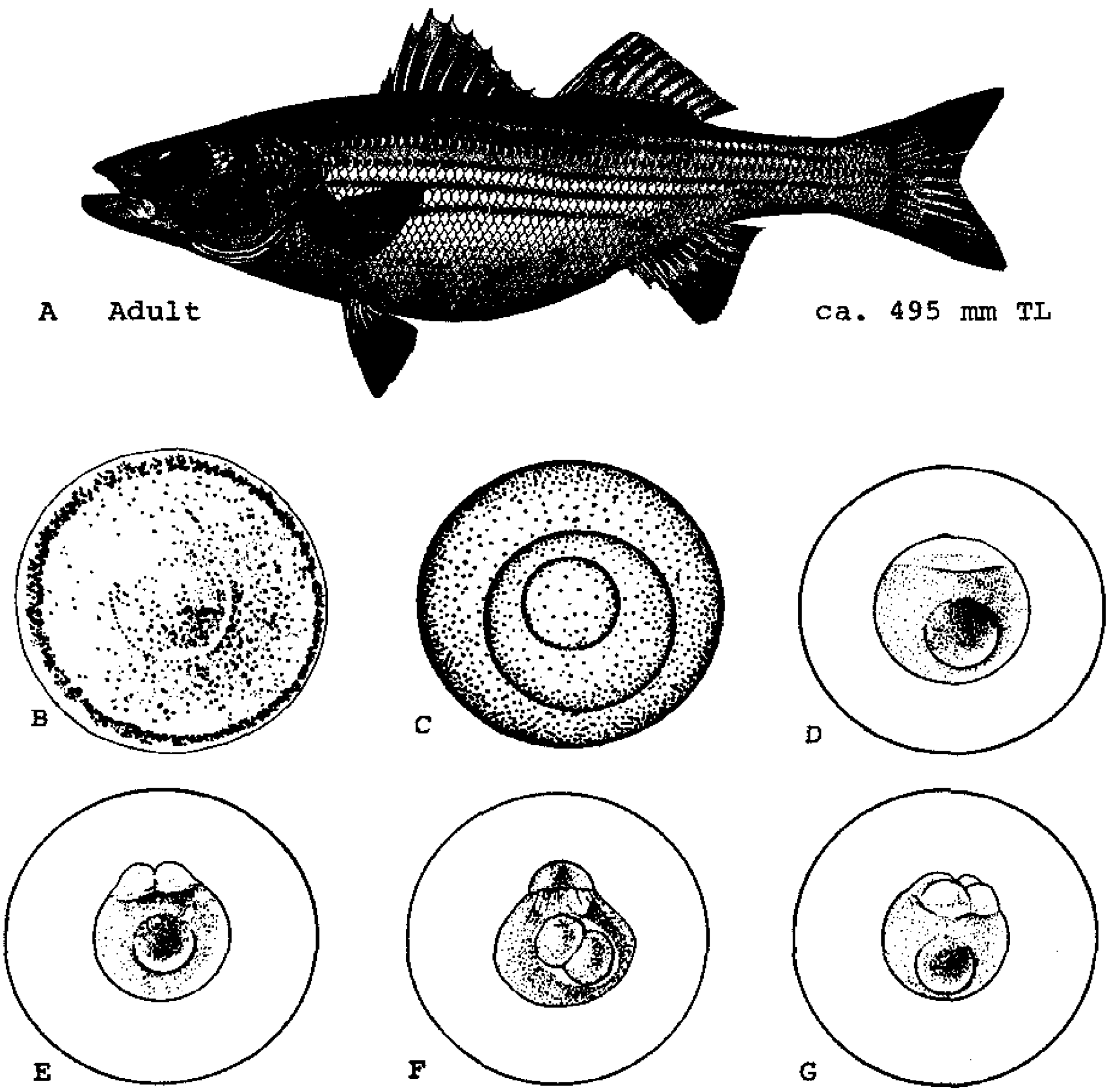


Fig. 50. *Morone saxatilis*, Striped bass. A. Adult, ca. 495 mm TL. B. Unfertilized egg, diameter 1.3 mm. C. Blastodisc, dorsal view. D. Blastodisc, lateral view. E. 2-cell stage, lateral view. F. 2-cell stage, dorsal view. G. 4-cell stage, lateral view, egg diameter 2.3 mm. (*A, Goode, G. B., 1884: pl. 170. B, D-G, Mansueti, R. J., 1958a: figs. 2–6. C, Pearson, J. C., 1940: fig. 4.*)

scales above lateral line at caudal peduncle 11–13, below 12–15;[3] total gill rakers first arch 19–29, upper arm 6–12, lower arm 12–15;[44,156] average first gill raker values Chesapeake Bay, upper arm 9.49–9.77, lower arm 12.61–13.07;[154] branchiostegal rays 7;[7] total vertebrae (including hypural) 24–25 (usually 25);[70,85,170] abdominal vertebrae 12; caudal vertebrae 13.[7]

Proportions as times in SL: Greatest depth 3.45–4.20; average depth at caudal peduncle 9.6, at anus 3.9; head length 2.9–3.25. Proportions as times in HL: eye 3.0–4.9.[156,206]

Body elongate, moderately compressed; back slightly arched; nape not noticeably depressed;[152,156] gape to middle of eye;[46] gill rakers long and slender[98] (but older specimens with fewer well-developed gill rakers than younger specimens);[152] teeth small, present in bands on jaws, vomer, palatines, and in two parallel patches on tongue;[20,206] two sharp spines on margin of opercle;[152] margin of preopercle clearly serrate. Scales extended onto all fins except spinous dorsal.[156] Dorsal fins clearly separated,[152] approximately equal;[156,214] caudal forked.[98]

Pigmentation: Light green, dark olive green,[156] silvery green,[61] silvery with brassy or coppery reflections,[127] to steel blue or almost black[83,156] above; lighter below.[46] Sides silvery[83,156] with 7 or 8 usually uninterrupted horizontal dark stripes, one of which always follows the lateral line and all but the lowest of which lie above the level of the pectoral fins.[45,61,214] Three to 4 stripes above lateral line, 3 below.[156] Belly whitish[61,83,156] or silvery with brassy reflections.[214] Vertical fins dusky green to black, pelvics white to dusky, pectorals greenish.[156]

Maximum length: Males 115.6 cm FL,[15] females possibly to 182.9 cm.[54] Maximum weight: 56.7 kg[31] (but a combined weight of 408.2 kg has been reported for five large specimens[154]).

DISTRIBUTION AND ECOLOGY

Range: St. Lawrence River, Canada, to St. Johns River, Florida,[65,202] and from Suwannee River in western Florida[58] to Lake Pontchartrain, Louisiana.[1,141,186] May move far inland, possibly up to 480 km above salt water in Alabama.[214] Naturally occurring landlocked populations are reported in South Carolina[40,73,95,104] and Mississippi,[88,186] and various river systems appear to have discrete endemic populations.[31,65,82,214] Introduced in California in 1879[67] and 1882.[125,128,167] Now on Pacific coast from Columbia River, Washington[1,25,53,152,173] (reports from Alaskan waters are unconfirmed)[152] to Baja California, Mexico (40 km south of the U.S./Mexican border).[59] Introduced into Salmon Creek, North Carolina in 1873[224] and into Colorado River in 1959.[41] Results of these introductions, unknown. Introduced into lakes and reservoirs (with varying results) in western Maryland, New Jersey,[73] Virginia,[81,83,207] North Carolina,[45,83,145] Kentucky,[88] Tennessee,[17,83,208] Arkansas,[72,174] Oklahoma,[16,185] and California;[73] also in Lake Ontario (fry from Havre de Grace, Maryland).[57,182] Attempted introduction into Hawaii.[84,205] Studies now being made in connection with possible acclimation in the Soviet Union.[108]

Area distribution: New Jersey;[43,96,141,163,166,210] Delaware;[18] Delaware Bay;[138,216,220] Delaware River;[87] seaside Maryland and Virginia;[110,111] throughout Chesapeake Bay, Maryland and Virginia;[71,117,118,133,135,205] formerly ascended at least 160 km above tidewater in Susquehanna River.[15]

Habitat and movements: Adults—typically an inshore[214] schooling species[93,126,152] usually found where at least some current is running,[126,152] over bottoms of rock, boulders,[152,214] gravel,[193] sand,[65,214] muck and detritus,[86] grass,[193] and moss;[126] also over mussel beds. In estuarine and marine environments specifically recorded along sandy beaches,[214] rocky shores,[31] shallow bays, troughs and gullies hollowed out by wave action, sand bars,[214] in surf,[124] and, sometimes, under rafts of floating rockweed.[214] Maximum distance offshore ca. 97–113 km, but such specimens are probably strays;[152] usually within 6.4 to 8.0 km of shore,[214] with few beyond 16 km[142] (records from offshore parts of Georges Bank are based on misidentified weakfish[214]). Enter rivers and creeks[51,65,87,180] and recorded from both natural[86] and man-made lakes.[16,45,73,81,83]

Depth 0.6[193] to 46 m,[83] with larger fish in deeper water.[87,130] Temperature range 0.1[88] to ca. 27 C, although kills may occur at the higher temperature[88,152,214] (for specific reactions to higher temperatures see Gift and Westman[212]). Normally avoid temperatures higher than ca. 18.5–21.0 C,[224] remain active down to 1.0 C,[192] and can withstand abrupt temperature changes.[25] Salinity range 0.0–35.0 ppt;[214,217] able to withstand abrupt salinity changes.[25]

Generally overwinter in bays, estuaries, delta regions, rivers, and, sometimes, the open sea, at depths of up to 37 m[35] and at minimum salinity of less than 10 ppt.[216] In Chesapeake Bay feeding and movement continues throughout winter, while in Delaware and New Jersey waters, fish congregate in deep holes and remain relatively inactive.[152] In Potomac River large fish found upstream to salinities of 7–11 ppt, beyond which body size decreases with decreasing salinity.[192]

Typically anadromous,[48] although sometimes strictly potadromous in certain landlocked lake populations.[16,45,73,81,83] and possibly in the Mississippi River.[186,221]

Spawning migrations begin as early as February[147] or March[86] and continue until early July (depending on latitude).[142] Males generally arrive on the spawning grounds before females.[152] Prespawning aggregations occur in Chesapeake Bay during January, February, and March [69] and upriver spawning migrations follow in April and May.[76] In Roanoke River, North Carolina, spawning migrations begin when water temperatures reach 7 or 8 C [156] (typically during March) and terminate at the spawning grounds, ca. 209 to 217 km upriver, around the first of April.[45,100,145] In the Santee-Cooper drainage, South Carolina, prespawning concentrations and spawning migrations occur in March, April, and early May, and there is a gradual postspawning movement downstream around the end of May.[164,196] On the Florida coast spawning runs occur from February [147] to May.[86] Spawning migrations formerly extended much further up some rivers than they do at present; in the Susquehanna, for example, ripe fish were recorded as far upstream as the forks at Northumberland.[76] In addition to spawning migrations, some striped bass from the coast of North Carolina, and the Chesapeake Bay undertake extensive annual coastwise migrations,[15,165,202,210,214] moving northward to New England and Canada [23,149,160] in April and May and returning between September and December (although some individuals may, in fact, overwinter in New England).[1,80,221] These movements involve fish 2 years old and older and may include some immature females.[142] Larger fish tend to migrate greater distances than smaller fish.[8] Maximum distance traveled, 1126 km; [15] maximum recorded speed, 443 km in 8 days.[149] The extent of involvement of North Carolina fish in this migration is not well known,[221] but at least part of the population remains in North Carolina throughout the summer.[100] In the Chesapeake drainage estimates of percent involvement vary from 1.5 of the Potomac River population to ca. 10 percent of the total bay population. The principal migration route may be up the Chesapeake Bay, through the C and D Canal and Delaware Bay, and northward along the coast.[15,27,81,137,149,150] Fish returning from northern waters apparently enter Chesapeake Bay through the C and D Canal.[213] Truitt reported a striking winter migration from the upper Chesapeake Bay to James River, Virginia, but pointed out that this did not occur in all years.[149] Few if any striped bass south of Cape Hatteras, North Carolina, take part in the annual coastwise migration.[214] Populations in southeastern Canada, the Hudson River, and, possibly, the Delaware River, may also be more or less isolated and probably do not move great distances after spawning. The Hudson River population, for example, moves only as far as Long Island Sound and the New York Bight.[68,82,213,214] There is evidence to suggest that the Delaware River population moves down the coast after spawning.[213,216]

Larvae—yolk-sac larvae lie horizontally on bottom,[133] but may also lie perpendicular in water column with head toward surface; [7,61] attempt to swim to surface, dropping back to bottom between efforts.[7,100,151] At 1 to 2 days larvae near surface, sometimes attached to floating objects; [7] by 3rd day show continuous swimming ability [108,176] and at ca. 4 to 5 days (in aquarium) form schools. Larvae positively phototaxic; at lengths of 5.5 to 5.8 mm remain essentially suspended in water column, never sinking to bottom.[107,108] Two weeks after hatching larvae forage at the bottom,[7,62] sometimes settling over silt and mud.[116]

In the Chesapeake Bay region larval nursery areas are the same as the spawning areas.[133] Larvae are found both in fresh and brackish waters (EMS) often in association with larvae of *Morone americana* (although the spawning areas of these two species may be kilometers apart).[175] In the Delaware River larvae have been recorded over a distance of 103 (or possibly 107) km, but are primarily in the first 13 river km above Delaware Bay.[138] Temperature range generally 11 to 22 C,[138] optimum 16–19 C; temperatures above 23 and below 11 are lethal.[108] Yolk-sac larvae specifically recorded at salinities of up to 2.1 ppt.[133] Otherwise larvae 0.0 [105] to 32.0 ppt.[105,133,220] Greatest density at less than 2.0 ppt.[105] Highest survival up to 10.0 ppt.[108]

Larvae of unspecified age and size drift with current.[2] There are indications of a general dispersal toward bottom as feeding begins.[7,62] When ca. 12 mm long schools move shoreward and remain in shore zone throughout first summer.[1,83] As summer progresses larger larvae move downstream, and by autumn some individuals have reached mouths of estuaries.[116,121]

Juveniles—juveniles in schools,[15,87,142] and small schools maintained into second year of life.[152,214] Juveniles of various sizes (or unspecified size) recorded from streams,[87,156] rivers,[37,197] bays,[1] sounds,[46] sheltered coves,[9] flats,[198] and freshwater ponds.[123] Young-of-the-year generally more abundant in areas with pronounced current.[11,62,90] "Immatures" abundant in shore zones of Delaware Bay; [158] specimens "several inches long" in schools around floats and wharves.[29] At 50 to 80 mm very mobile, sometimes leaping out of water.[108] Generally found over clean sandy bottom,[5,11,62,142,217] but also over gravelly beaches (at average length of ca. 50 mm),[152] and, at 71 to 85 mm, over mixture of mud, sand, gravel, and rock; [156] rarely over soft bottom.[62] Young and juveniles generally in shallow water,[54,181] although "fingerlings" recorded from holes over 30.5 m deep in Chesapeake Bay.[121] Typically more concentrated over shoals than in deeper water.[181] Specimens 71 to 85 mm long specifically recorded in water 2.4 m deep.[156]

Recorded temperature range 3.55 [154] to 35 C.[88] Overwinter at 3.55 to 6.0 C.[154] Preferred temperature in specimens 80 to 149 mm long varied from ca. 15 C in December to ca. 26 C in October.[211] One year old fish avoided 29.5 C waters, but avoidance capacity broke down by 33.5 C. An upper lethal temperature of ca. 35 C has been reported for young-of-the-year.[212] Juveniles appear to be less tolerant of abrupt changes in temperature than adults.[25] Variously reported at salinities of 0.2–16.0 ppt.[5,105] In summer months subadults prefer salinities greater than 2.0 ppt; specimens less than 2 years old usually at salinities below 12 ppt.[216] At 20–30 mm can withstand transfer from 0.0 to 17.8 ppt; [108] and juveniles of unspecified age or size have survived transfers from 0.0 to 35 ppt.[217] Young fish appear to be less able to adapt to abrupt salinity changes than adults.[43] Fish 100 to 170 mm long died when transferred from fresh water at 21.1 C to 35 ppt at 7 C, but survived the reciprocal transfer.[108]

There is a general downstream movement of juveniles,[102,133] but this movement may be more pronounced during the 2nd summer (in fish having a length of ca. 150 mm or more). Such fish may be found in lower reaches of rivers or may have entered bays and sounds.[1,50,62,83,123]

In the Chesapeake Bay region young-of-the-year released at the mouth of Patuxent River remained in shoal area in summer; 5 to 16 months later some of these fish were captured 80 km or more up the Bay. Young-of-the-year released 27 to 53 km up the Patuxent in fall and winter remained more or less stationary although there were indications of a net upriver movement extending into virtually freshwater. In the following summer (2nd year) there was a definite movement downriver and into the Bay.[143] Ritchie found that fish hatched in the Patuxent moved up the Bay in their 2nd to 4th year.[146]

Striped bass apparently remain in the Potomac during their first 3 or 4 years.[181] Two year old juveniles released at Annapolis went northward to Havre de Grace and Elk River and eastward to Rock Hall and Chester River.[129] In upper Chesapeake Bay juveniles primarily remain in nursery areas, although some pass through the Chesapeake and Delaware Canal into Delaware Bay.[146] Juveniles which are in deep water in lower estuaries in November and December move into holes over 30.5 m deep in the Bay in February and March.[121]

In California maturing males (as well as small mature females) move into the delta region in spring, followed by immature females in summer.[181] A seasonal change in vertical distribution of California "juveniles" has been noted. During the fall and winter juveniles were concentrated near the bottom, in spring some fish were in midwater, and by summer juveniles were definitely concentrated in midwater.[78]

SPAWNING

Location: Principal spawning areas in the northeastern United States are Chesapeake Bay, Delaware Bay, and Hudson River; [123] 11 major spawning sites have been identified in Chesapeake Bay.[117] There is no evidence of successful spawning in coastal areas of New Jersey, and spawning either does not occur or is of rare occurrence in rivers of New England.[89,152] Spawning may have occurred in the Connecticut River,[5] but there is no evidence that this is now true,[213] although adults still enter the river each year.[89,213] There are reports of spawning in the Thames River, Connecticut; [144] ripe females have been taken in Mouson River, Maine; [140] and, based on the presence of larvae, spawning occurs in Shubenacadie and Annapolis Rivers, Nova Scotia [58,221] and in the St. Lawrence River, Quebec.[102] Merriman stated that spawning probably occurred in every river of any size in the northeastern United States where proper conditions existed.[203] The Susquehanna River was formerly the area of greatest egg production [105] and spawning was recorded as far upriver as Northumberland, or, possibly, beyond.[76] Following construction of Conowingo Dam the principal area of egg production appeared to be the main channel of Chesapeake Bay between Western Point and Chesapeake City.[105] Recently the major spawning activity has centered in the Chesapeake and Delaware Canal where Johnson and Koo recorded a density of 36 eggs/m.[3,218] In the Potomac River spawning formerly occurred as far upriver as Great Falls,[76,187,209] but now apparently stops at Whitestone Point.[150] Murawski reported larvae over a distance of 108 km in Delaware River, but this distance included a 45 km void in the vicinity of Philadelphia.[138] Changes in spawning patterns have probably occurred elsewhere as a result of environmental modification. Bailey, Winn, and Smith note that *Morone saxatilis* apparently no longer ascends the Escambia River, Florida.[30] Spawning occurs in fresh, turbid water [71] in shallow parts of rivers [56] (0.3 to 6.1 m [67]), streams,[6,13] and creeks; [87,138] probably never in lakes [214] and freshwater reservoirs [1] as has been reported, and never in the sea.[224] May spawn in the upper tidal reaches of rivers [49,141,152,153] or in areas just above the tide,[214] or may run upstream, sometimes as much as 320 km above salt water [142] and spawn in turbulent, muddy, silt-laden riffle areas. Such areas are frequently associated with the Fall Line and are characterized by rapids, boulders, and strong currents.[15,38,88,152] In the Chesapeake Bay region spawning occurs over bottoms of sand or mud.[49,152] In California spawning occurs over flooded islands and, consequently, sometimes over heavy growths of tules and algae, as well as in blind sloughs, swampy areas, and over extensive mud flats.[67,74] Egg survival may depend on sufficient current to keep them suspended [122,214] (a minimum of 30 cm/sec),[218] and best production occurs in large volumes of moving water.[62,88,90,142,145,151] For example, at Weldon, North Carolina, the Roanoke River falls 15.2 m in 9.6 km,[98] the current is strong (206 cm/sec) [153,156] and erratic, and the water muddy. Spawning takes place on or near the rapids among islands, boulders, and rocks [5,15,98] as well as in quieter parts of the river (although eggs deposited in quieter water may not survive).[145] In lower reaches of rivers egg suspension is accomplished by tidal action or spring freshwater run-off.[153] Eggs have been observed in upper tidal reaches of rivers in Chesapeake Bay where current varies from 112 to 134 cm/sec.[49,152,153] Some populations are quite sensitive to flow rate. In the Roanoke River (at Weldon) fish will not enter the spawning area during periods of low discharge from an upstream impoundment, or during periods of excessively heavy discharge.[145] While spawning may take place in areas having no pronounced current,[71] it is unlikely that the eggs survive (JDH). An early report of spawning in still waters of a bayou in California was based on ripe adults, not actual spawning.[152]

Regionally spawning is regarded as most intense within the first 40 river km above salt water,[1,71,138] but distance in individual rivers may be highly variable. In York River, 56 to 96 km, with center of activity at 64 km; [133] in Potomac River, over distance of 48 km from Cedar Point to Whitestone Point; [150] in Patuxent River, mostly in 11 km section between Lyons Creek and Upper Marlboro; [14] in Elk River, 4.8 to 14 km; in Nanticoke River, 32 to 45 km; [204] in Bohemia River, ca. 5 km; in Wicomico River, mostly 19 to 22 km; in Chester River, 45 km.[180] In Delaware River over a distance of 107 km from river km 94 to 201.[138,215]

Major spawning grounds within an individual river may change from year to year.[40,114] In Sacramento River annual variation is as much as 240 km (from river km 32 to 273) and these distances may vary as a result of differences in rate of seasonal warming (further upstream in slow warming years) or with amount of total dissolved solids.[79,148] Other annual differences have been documented, but not explained. Thus in the Staunton River, Virginia, in 1959, spawning occurred 26 km above Kerr Reservoir; in 1960, spawning occurred 69 km above the Reservoir; and in 1969, the major spawning area was between 35.5 and 84.3 km upriver from the reservoir.[171,172,207]

Other miscellaneous spawning sites have been described as follows: Congaree River, South Carolina, main area at river km 60, but up to 72 km; Wateree River, South Carolina, mostly below 51 km, but up to 93 or 96 km; [157] Tar River, North Carolina, over 80 km section, but 75% within 32 km area; [49] Roanoke River, North Carolina, 87 to ca. 220 km (48 to 129 km above salt-fresh water interface), but mostly at 174 to 209 km; [145,148] Dan River, Virginia (in 1969), 52.6 to 68.4 km; [207] Hudson River, most eggs in first 40 km of essentially fresh water.[62,159]

Season: February to July (or possibly August based on presence of ripe eggs) and varying with latitude.[49,97,147,152] In Chesapeake Bay region April [117,133,152,218] to July,[40,154] but primarily in April, May, and June.[1,23,105,193,214] In Delaware late May to mid-July,[152] but mainly in June.[152]

Spawning in extralimital areas as follows: in Mississippi mid-February to mid-March (on basis of well-developed roe); [186] in Alabama in April; [152] in eastern Florida, mid-February to end of May [147] (but also reported as probably near mid-winter in St. Johns River [65]); in South Carolina, March 16 [95] to June 5,[28,157] but primarily from April 1 to May 15; [13,60,162] in North Carolina, arrive in major Roanoke spawning grounds in March,[100] and spawn from April 11 to June,[49,156] but primarily from late April and May,[23] and in Tar River April 14 to May 18,[49] in Hudson River, ca. May 17 to June 16,[62,90,152] with greatest activity during last 2 weeks of May; [159] in New England, June and early July; [112,113,214] in California, mid-March to late July [53,74] (although mature eggs observed as late as August 8),[53,67] principally in May [42] or June,[152] but with year-to-year variation, thus in Sacramento-San Joaquin first of May to end of June in 1948, first of April to middle of June in 1949; [2,42] in Oregon, some females ripe until August.[97]

Peak activity: In Chesapeake Bay region 1 to 3 peaks occur during each spawning season,[117] with the major peak occurring any time during the last half of April or the first week of May.[7,109,191] Spawning peaks are probably triggered by noticeable increase in water temperature, and vary greatly from year to year. In Roanoke River, North Carolina, number of peaks varied from 1 (in 1963) [114] to 3 (1966) [199] or 4 (1961, 1962).[114] Dates for major peaks in 1961 and 1962 varied by 10 days.[115] Major peaks in the Roanoke River usually occur in May,[50,114,187] rarely in late April.[63] In the Dan River, 3 (1965) and 4 (1966) peaks have been observed, always in April and May.[114,117,199] Data for other spawning peaks are: South Carolina (Congaree and Wateree rivers) 3 peaks each (1961, 1962), all in April and May, and primarily in May,[157] (Santee-Cooper) April 21 to May 5; [162] North Carolina (Tar River), peaks generally between May 3 and 11; [49] Virginia (Staunton River), 2 peaks, both in May; [171] California, peaks vary from last week in April to middle of May; [2] Oklahoma (Cimarron River) peaks April 28 and May 6, both during time of falling water.[185]

Time: Highly variable, and with little information for Chesapeake Bay region. Eggs taken in Susquehanna River "during the early half of the night were probably only a few hours spawned." [151] In South Carolina (Congaree and Wateree rivers) more or less equally divided between day and night, with slight preference for day; [28,157] North Carolina, late afternoon or early evening; [45] Virginia (Staunton River) primarily between late evening and early morning, (Dan River) early to late afternoon; [171] California, 1500 hours until noon of following day; [56] Oregon (Coos Bay), throughout day but primarily late afternoon and early evening.[97,152]

Duration: 8 [117] to 44 [28] or possibly 56 (based on presence of eggs) days. In Chesapeake Bay only 8 days in 1964 (against a steadily rising temperature), 38 days (and interrupted by cold periods) in 1963; and generally with bulk of spawning occurring within about one week after temperatures reach 12.7–15.6 C.[117] On Potomac River from 2nd week of April to 3rd week of May during 1974, from 3rd week of April to 4th week of May during 1975, and from last week of March through first week of June in 1976.[223] In Roanoke River ca. 14 to 35 days.[52] In

South Carolina 25 to 44 days.[28,156]

Temperature: Range 10.0 [83] to 25.0 C [156] (although one author states temperature observed throughout season as up to 25.6 C [2]). Generally starts at 14.4 C, peaks at 15.6 to 19.4 C, and ends at 21.1 to 22.2 C.[2,34,49,85,147] In Chesapeake Bay 10.4 C (based on presence of eggs) [133] to 23.9 C,[117] mostly at 14.4 to 21.1 C,[152] and with peak activity at 17.8 to 20.0 C.[63] Peak activity has been observed to follow a temperature rise of 3.5 C.[14] In Delaware mostly at 12.2 to 19.4 C.[138] In Staunton River, Virginia, when temperatures are rising through 14.4 to 25.0.[199] In Roanoke River, North Carolina, 12.8 [187] to 25.0 C,[156] optimum and peak activity at 16.7 C [187] to 20.0 C.[51] In South Carolina, first eggs in Congaree-Wateree area at 14.4 C.[157] In California 14.4 [79] to 23.9 C,[53,55,67] mostly at 16.1 to 20.6 C,[79,138] but varies locally, thus in lower Sacramento begins at 15.6 C, in Delta region sometimes at 14.4 C, with peak at 15.6 to 19.4 C.[152] Spawning occurs on a rising temperature,[177,207] and may cease during storms or following a sudden temperature drop.[42,55,79,117]

Salinity: Several authors have commented that spawning may take place in brackish water (up to 2.0 ppt) [49,56,62,105,133,152] but these observations are based mostly on the presence of eggs (which may have drifted from freshwater) and there is little real evidence for spawning outside freshwater.[152] Bason, however, recorded non-water-hardened egg at a salinity of 6.0 ppt and suggested that spawning may have occurred near this salinity.[216] In California spawning migrations are blocked when total dissolved solids reach 350 ppm, and spawning does not occur in water having more than 180 ppm dissolved solids.[79,132]

Fecundity: Two types of eggs, ripe and immature, have been described, but it is possible that eggs for three consecutive seasons may be contained in the ovary simultaneously.[64,161] The presence of this variety of eggs may account for wide differences in fecundity estimates. Fecundity range, 10,000 (probably based on mature eggs) [45] to 40,507,500 (based on total number of eggs in all stages of maturity).[19] Published averages are 684,000 [21] and ca. 700,000.[98] Estimates of the number of eggs per kg vary from 136,700 to 246,900.[200] Estimates of fecundity related to age are: 4 years old, 65,000; 13 to 14 year olds, 4,500,000.[19] Specimens 45.7 cm long may produce 15,000 eggs, those 111.8 cm long, 5,000,000 eggs.[15]

Typical fecundity estimates based on weight are as follows:

0.9 to 1.3 kg	average 163,000 [123]
1.4 kg	ca. 14,000 [142,202]
1.8 kg	429,000 [117]
2.0 kg	total 733,601
	mature 68,239 [19]
2.0 kg	265,000 [214]
2.3 kg	5,000,000 [142,202]
4.0 kg	900,000 [97]
5.4 kg	1,280,000 [5]
5.9 kg	1,337,000 [151]
6.8 to 7.2 kg	average 1,029,000 [200]
14.5 kg	total 40,507,500 [19]
15.9 kg	4,536,868 [19]
22.6 kg	3,220,000 [21]
	4,775,000 [97]
28.7 kg	5,300,000 [117]
29.5 kg	5,326,000 [117]

Behavior: There is evidence that females separate themselves in groups according to ripeness [60] and that larger females spawn earliest in the season.[117] Spawning fish apparently eat little or nothing, but the fasting period is probably brief.[139,152] Neither males nor females necessarily develop eggs or milt each year.[82] A single female probably completes spawning within a few hours,[209] and spawns only once a year,[53] casting all of the eggs at one time.[17]

EGGS

Location: Deposited near surface.[142] Buoyant,[7] or semi-buoyant,[1,5] and found at various levels in water column from surface to bottom; in California mostly within 1.5 m of bottom in water 4.6 to 10.7 m deep.[152] Slightly heavier than freshwater [7,142] (specific gravity 1.0003 to 1.00065, $\bar{x}$ 1.0005 [34,88]), but easily floated by agitation.[5,7] Larger eggs possibly more buoyant than smaller ones.[34] Specific gravity changes during early development. Immediately after fertilization less buoyant (a vertical water movement of 125 cm/sec required to suspend the eggs); within 2 to 3 hours more buoyant (60 cm/sec required for suspension). After 12 hours unfertilized eggs become opaque and more buoyant than fertilized eggs.[176]

Drift with current,[2] sometimes at speeds up to 2.06 km per hour (and for distances up to 150 km).[114] Recorded in currents of 54.4 to 269.6 cubic meters/sec; [171] generally concentrated near bottom at current velocities of less than 30 cm/sec.[34] Talbot felt that unsuspended eggs have poor chance of survival.[88] Stevens commented that they must have current or perhaps sandy or rocky areas where partly developed eggs and larvae may settle in highly oxygenated water and escape suffocation.[179] Bayliss demonstrated that eggs will hatch without any period of suspension, although the percent hatch increased with length of suspension period during first 15 hours. He found the following percent hatches on various substrates: coarse sand, 35.7; plastic, 36.4; silt, 13.1; silty clay, 3.2; muck-detritus, 0.0.[194] Large numbers of eggs are sometimes stranded in windrows on beaches.[118] Sunlight apparently enhances egg survival.[34,108]

Found at salinities of up to 12.0 ppt,[21,105,216] and viable eggs in Chesapeake Bay at 11.3 ppt.[117] Development

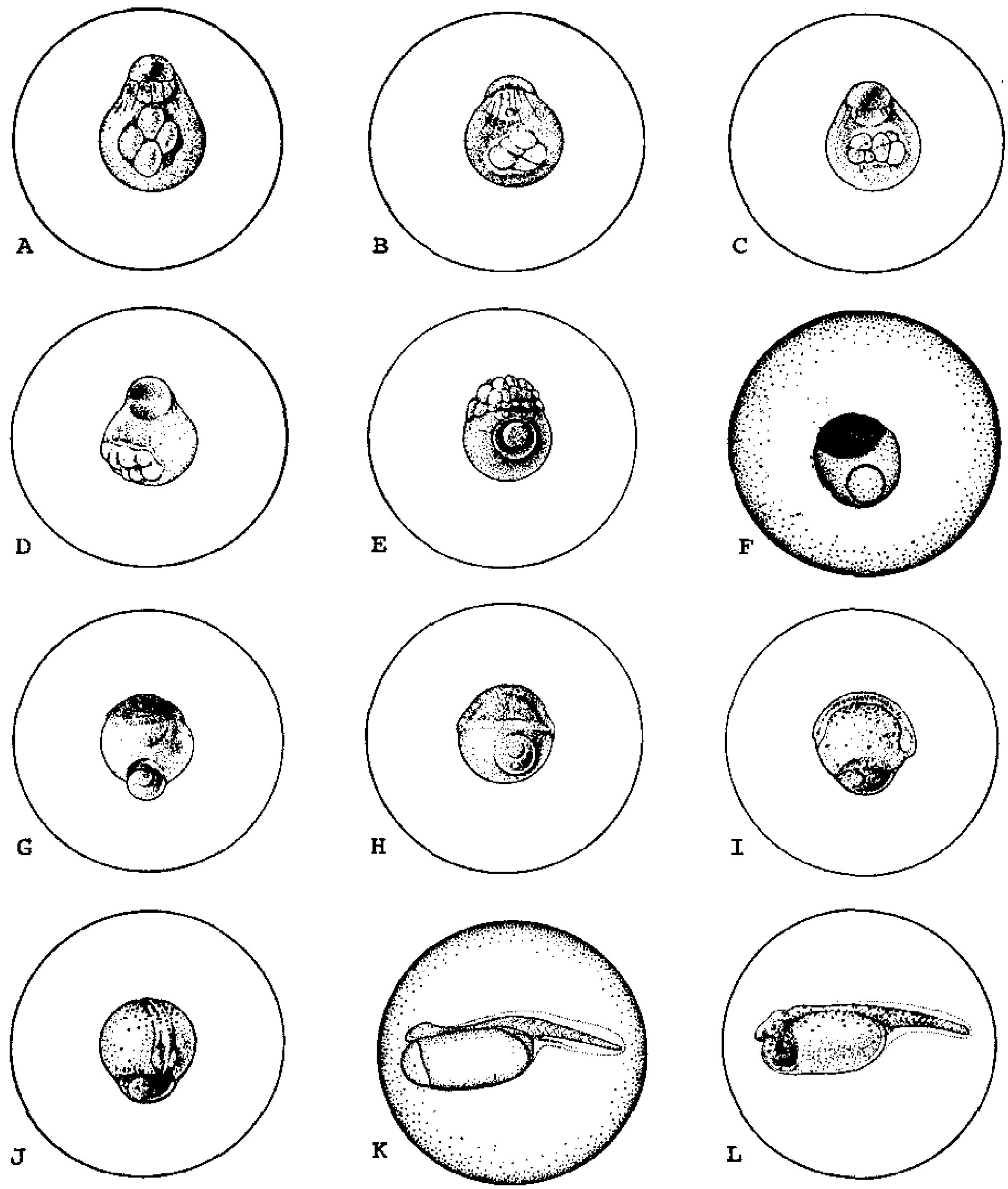


Fig. 51. *Morone saxatilis*, Striped bass. A. 4-cell stage, dorsal view. B. 4-cell stage, lateral view. C. Atypical cleavage, 5-cell stage, dorsal view. D. Atypical cleavage, 7-cell stage, diameter 3.4 mm. E. 32-cell stage. F. Morula. G. Morula or early blastoderm. H. Blastoderm to yolk equator, germ ring and embryonic shield evident. I. Early embryo, pigment evident. J. Early embryo, anterodorsal view. K. Advanced embryo, tail free and straight, lens not evident. L. Advanced embryo, lens and pigment well-developed, length 2.5 mm, egg diameter 3.5 mm. (*A-E, G-J, L, Mansueti, R. J., 1958a: figs. 7–16. F, K, Pearson, J. C., 1940: figs. 5, 8.*)

will proceed at 20.0 ppt, but larvae die within 48 hours.[108] Eggs found at 4.7 to 9.7 ppt hatched and the larvae survived,[117] although, under experimental conditions, survival decreased at salinities above 4.74 ppt.[215] Maximum survival occurs at 0.900 to 0.948 ppt.[34,86]

Unfertilized eggs: Ovarian eggs of various sizes form homogeneous matrix in ovary;[152] opaque,[200] yolkless at 0.01 to 0.23 mm.[19] Yolk formation begins at 0.16 to 0.30 mm.[12] Eggs ready for release at 0.70 mm.[200] Ripe eggs 1.0[56,152] to 1.50 mm,[12] averages stated as 1.32 mm[7] and 1.35 mm;[152] perivitelline space lacking; yolk green, oil globule amber, at top of yolk mass, ca. 1/2 diameter of shell.[7] Color shifts from cream or creamy yellow to yellowish green and darker green as eggs ripen. Shift begins at ca. 0.7 to 0.8 mm[13,58] ($\bar{x}$ 0.76 mm[152]); mature eggs are bright green with transparent membranes.[4,144] Smith, Boner, and Tatum examined freshly ovulated eggs from Weldon, North Carolina, which had crystal clear perivitelline fluid, consolidated oil globules, and a hexagon shape. In examples from the Carolina coast, oil globules were consolidated in only 50% of the eggs; the perivitelline fluid was granular.[178]

Maturation of the eggs apparently depends on temperature. When daily minimum temperatures remained below 17.2 C, fish injected with chorionic gonadotropin produced first eggs in 48 hours; at 17.2 C or higher, eggs were produced in 24 hours.[178] Eggs remain viable for about one hour after release from the follicles into the lumen of the ovary.[179]

Nonwater-hardened eggs: 1.25 to 1.80 mm,[1,10,36,151] averages stated as 1.25,[36] 1.58,[10] and 1.78 mm.[56] Fifteen minutes after fertilization, 1.84 mm.[151]

Fertilized eggs: Spherical, nonadhesive,[1,7,33] nearly or quite transparent[7,10,36] (probably depending on age), various shades of green, at least when first spawned,[75,100,118,201] but apparently losing color and becoming almost invisible as development proceeds.[201] Yolk green or golden green, lightly granulated, diameter 0.90 to 1.50 mm ($\bar{x}$ 1.18 mm). Usually a single amber oil globule (diameter 0.40 to 0.85, $\bar{x}$ 0.61 mm), and sometimes several additional small ones. Size range, water-hardened eggs, 1.02 (although identity of these eggs questioned, otherwise 1.30 mm)[138] to 4.6 mm.[34] Maximum diameter, Chesapeake Bay region, 3.95 mm.[15] In California size varies from 3.2[138] to 4.6 mm.[34] Mean egg sizes in various localities: North Carolina, 2.43 to 3.63 mm; Patuxent River, Maryland, 2.18 to 2.23 mm;[7] Delaware tributaries, 1.65; Delaware River, 2.90 mm. Small egg size may be related to high salinity[138] or other factors. In one experiment eggs reared in pond water were 3.0 mm in diameter, but in well water only 2.0 mm in diameter.[134] Perivitelline space very wide, 65 to 85% of diameter[1,7,10] (abnormally small eggs from Chesapeake Bay region lacked typically wide perivitelline space,[117] but the identity of these eggs has been questioned[189,206]). Egg membrane transparent,[151] variously described as thin and delicate, heavily corrugated,[7] and smooth.[36]

EGG DEVELOPMENT

Development at 16.7 to 17.2 C (Mansueti series):[7]

0 to 5 minutes.	Perivitelline space begins to form.
Ca. 20–40 minutes.	2-, 4-, and 8-cell stages.
1 hour.	4- and 8-cell stages predominate, few 16-cell stages, perivitelline space still not fully enlarged.
2 hours.	4- to 32-cell stages, perivitelline space fully formed.
4 hours.	4- to 64-cell stages, blastoderm berry-like.
8 hours.	16-cell stages to morula, blastoderm granular in appearance.
12 hours.	32-cell stages through gastrula, blastoderm covers one-half of yolk.
16 hours.	64-cell stages through gastrula, blastocoele forming, germ ring thickened around periphery of blastoderm.
20 hours.	Embryo developed, neural ridges and eyes visible, pigmentation present on embryo and oil globule.
24 hours.	Embryo ca. 1/2 around yolk, pigment intensified on dorsolateral region of body and adjacent blastoderm.
36 hours.	Embryo ca. 1.6 to 2.0 mm long, posterior part of body free from yolk, eye well differentiated but not pigmented.
48 hours.	Hatching.[7]

Development at average temperature of 17.9 C (Pearson series):[151]

At 15 minutes.	Size increased, blastodisc evident at one end of yolk sphere, chorion less corrugated.
12 hours.	Egg greatly enlarged; chorion thin, transparent, fragile; blastoderm in late cleavage; periblast clearly differentiated; green pigment of yolk less intense.
24 hours.	Embryo halfway around yolk, small dots of pigment over dorsal aspect of body and part of adjacent blastoderm.
36 hours.	Embryo ca. 1.6 mm long; eyes formed, unpigmented; posterior part of body free from yolk.
48 hours.	Hatching.[151]

Notes on development: Blastodisc appears on side of yolk at 90 degrees to oil globule which lies at top.[156]

Embryos "kick" in egg at 40 hours (temperature not stated).[108] Advanced embryos lie fully extended and float free within the egg.[36] There are from 16 to 24 somites.[10]

Incubation temperature: Eggs have been found at 8.0 to 25.0 C,[105] but probably do not survive well if at all at these extremes.[133] Can survive constant temperatures of 12.8 [34] to at least 22.2 C [147] (although one author reported 100% mortality in eggs reared at 21.1 C and above [108]). Best hatches at 19.9 to 20.5 C; very few hatch at extremes of 11.1 and 26.6 C.[34]

Incubation period:

At 12.2 C	80 hours [7,108]
At 14.4 C	54 [108] to 74 hours [5,7,15,17,61,152]
At 14.4 to 15.5 C	ca. 70 to 74 hours [49,73,152,155,156]
At 15.0 C	72 [7,108] to 73 hours [114]
At 15.0 to 16.0 C	ca. 48 hours [133]
At 15.5 to 15.6 C	ca. 50 to 70 hours [108,122]
At 15.6 to 17.8 C	48 to 72 hours [88]
At 16.7 to 17.2 C	36 to 48 hours [7,108]
At 17.2 C	48 hours [108]
At 17.8 to 17.9 C	48 hours [1,7,49,51,108,142,151]
At 18.3 C	43 to 48 hours [7,83,108,122,202,218]
At 18.9 to 19.4 C	48 hours [7,108]
At 19.4 C	38 to 48 hours [5,7,108,152]
At 21.1 C	33 to 48 hours [46,49,152,156]
At 21.6 to 21.7 C	36 hours [7,108]
At 21.6 to 22.2 C	ca. 30 to 44 hours [26,49,152,156]
At 22.2 C	30 hours [7,15,108]
At 23.9 C	29 hours [114]

A report of incubation lasting up to 5 days [75] is probably in error (JDH); the usual period is 2 to 3 days.[4]

YOLK-SAC LARVAE

Length at hatching, 2.0 to 3.7 mm,[7] mean 3.1.[10] Maximum length, ca. 6.0 to 7.0 mm.[36] At 2 days 4.5 to 5.2 mm long. At 8 days 5.8 to 6.5 mm, yolk 3/4 gone.[108] With temperature differences of 1.5 to 2.5 C having significant effects, yolk and oil absorption highly variable: 3 days at 23.9 C, 6 days at 16.7 to 17.8 C;[34] also estimated at 7 [67] to 14 days, with traces of oil sometimes remaining until 22nd day.[108] Although one author recorded active feeding in specimens thought to be 24 hours old,[101] feeding is generally thought to begin in 4 to 10 days.[52,120,171,184,188]

Total myomeres 17 to 25 (average 22),[10] 21 to 23 at 4.5 to 5.2 mm, 24 to 25 at 5.5 to 5.8 mm; [108] preanal myomeres 8 to 12, average 10; postanal myomeres 9 [15] to 15,[23] average 12 [10] (at 4.5 to 5.2 mm, 12 to 14; at 5.5 to 5.8 mm, 14 to 15 [108]).

Average proportions expressed as percent average SL: greatest depth, at 2.5 to 3.0 mm 44.2, at 5.5 to 6.0 mm, 17.2; distance snout to anus, at 2.5 to 3.0 mm 74.1, at 5.5 to 6.0 mm, 54.7; eye diameter, at 3.0 to 3.5 mm, 7.1, at 5.5 to 6.0 mm, 6.2.[7]

Body long, slender, tadpole-like at hatching.[10] Yolk mass initially oval,[152] oil globule projected beyond head or at least anterior to eye; [10] at ca. 4.4 mm head projected beyond oil globule; [151] yolk sac decreased 20%, oil globule 11% in specimens 2 days old and 4.5 to 5.2 mm long; at 5 days and 5.5 to 5.8 mm yolk ca. 1/2 original size; at 8 days and 5.8 to 6.5 mm yolk 3/4 absorbed, size of oil globule highly variable.[108] Mouth not evident at hatching,[7] formed or forming at 2 to 4 days or at length of 4.5 to 5.2 mm,[7,52,108,151] but possibly not functional for as much as 10 days after hatching.[188] Teeth initially evident at ca. 3.3 to 5.8 mm.[10] Doroshev found 5 to 7 teeth in specimens 5.8 to 6.5 mm long (8 days old),[108] while Mansucti noted a single fang-like tooth at ca. 6.0 mm and 1 to 5 teeth at sizes of 6.2 to 6.7 mm. Choroid fissure apparently not evident beyond 5.5 mm; [7] eye mobile at 8 days or length of 5.8 to 6.5 mm. Divisions of brain clearly evident at 4.5 to 5.2 mm. At 5.8 to 6.5 mm (8 days) gill almost completely covered.[108] Dorsal finfold extended forward to head in most specimens; preanal finfold evident throughout stage. A ventral thickening in the urostyle at ca. 5.0 mm. Incipient caudal rays sometimes evident at 6.0 mm. Pectorals first evident at 4.4 mm, fan-shaped and with distinctly fleshy bases at 5.0 mm, with incipient rays at ca. 6.0 mm. Pectoral base vertically oriented at 8 days (5.8 to 6.5 mm).[7,108,151] Intestine well differentiated by 2nd day; [108] initially angled sharply downward immediately behind yolk, much less angled by end of stage; [7,10] intestine distinctly folded, peristalsis clearly evident by 5th day (5.5 to 5.8 mm); sphincter between hindgut and stomach clearly visible, gall bladder yellow-green or pure green by 8th day (5.8 to 6.5 mm). Gas bladder possibly evident at 5.0 mm,[22] not filled at 5.5 to 5.8 mm. Erythrocytes either colorless or light orange at 4.5 to 5.2 mm, fully pigmented at 5.5 to 5.8 mm.[108]

Pigmentation: Apparently more or less transparent during entire yolk-sac stage.[108] At time of hatching melanophores generally concentrated on dorsolateral aspects of head, over lateral and anterior aspects of oil globule, along dorsal surface of yolk sac, and irregularly along sides of trunk and tail; eyes unpigmented; [7] oil globule amber.[21] At unspecified length (but in specimen with large yolk sac and distinct choroid fissure) orange chromatophores (mixed with black melanophores) on oil globule, posterior part of yolk sac, and along midline of

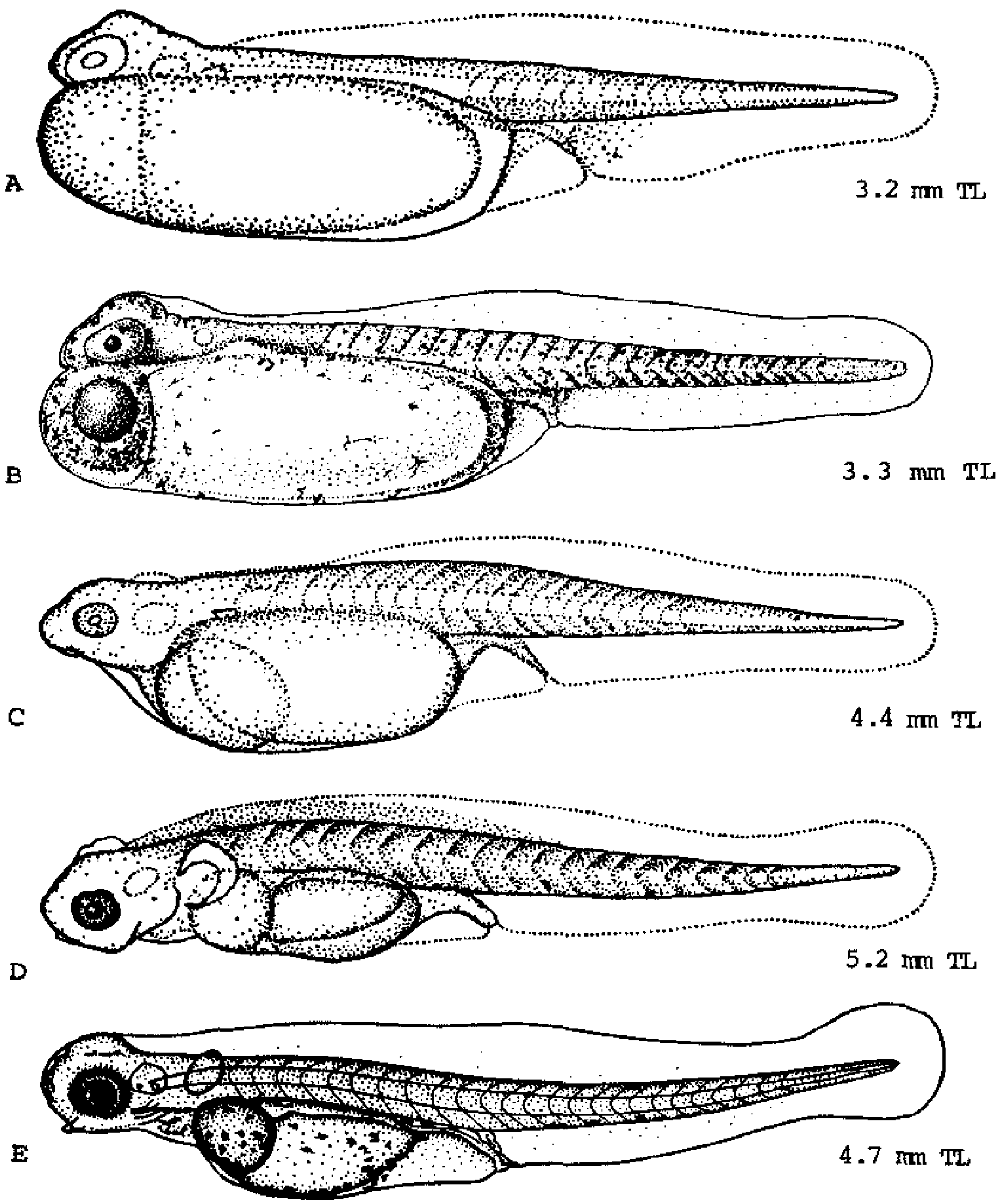


Fig. 52. *Morone saxatilis*, Striped bass. A. Yolk-sac larva, 3.2 mm TL. B. Yolk-sac larva, 3.3 mm TL, somewhat more advanced than previous specimen. C. Yolk-sac larva, 4.4 mm TL, head extended forward of yolk. D. Yolk-sac larva, 5.2 mm TL, pectoral fin expanding, fan-like, mouth apparently open. E. Yolk-sac larva, 4.7 mm TL. (*A, C-D, Pearson, J. C., 1940: figs. 9–11. B, Mansueti, R. J., 1958a: fig. 17. E, Doroshev, S. I., 1970: fig. 2.*)

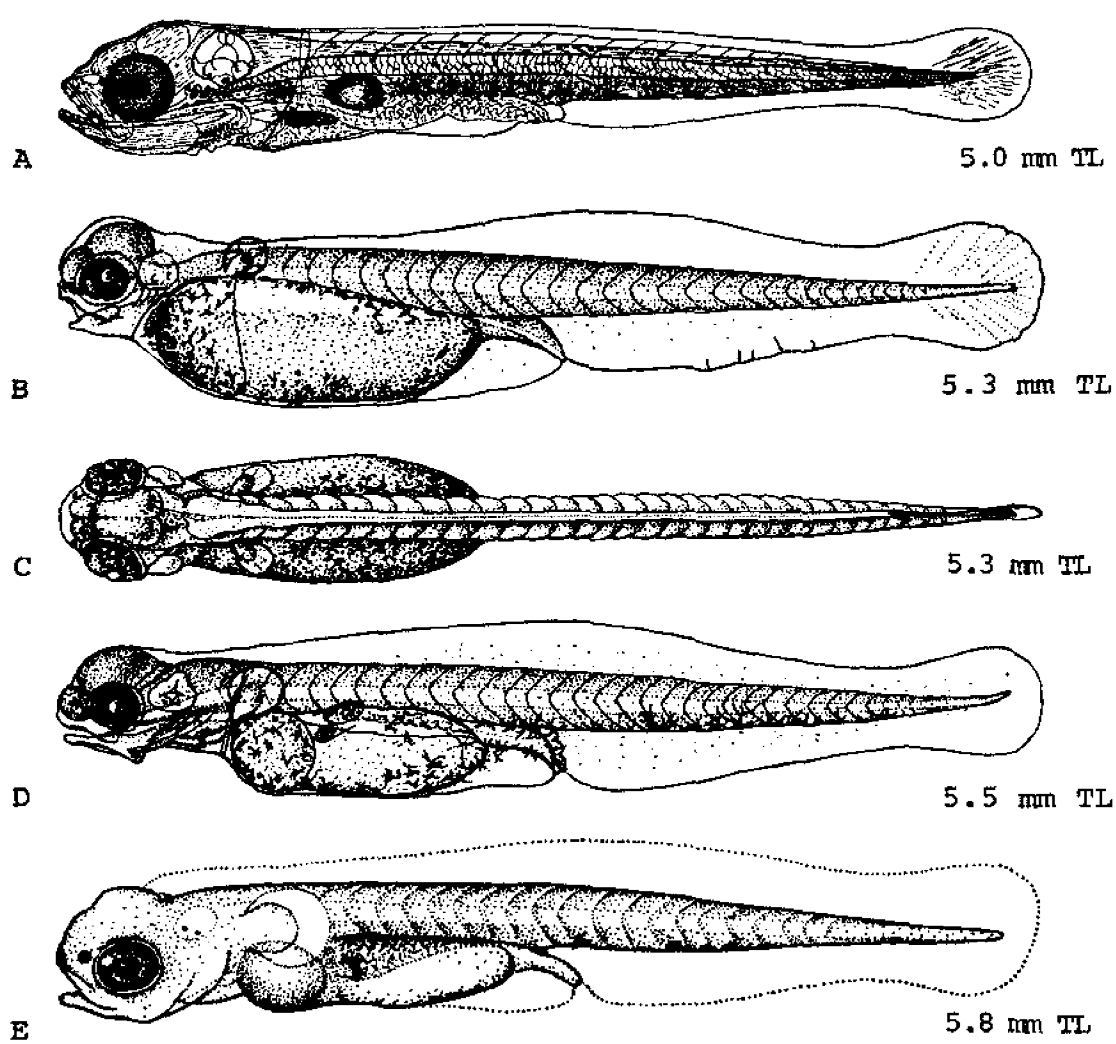


Fig. 53. Morone saxatilis, Striped bass. A. Apparent larva (identity questioned, JDH), 5.0 mm TL, gas bladder formed, head juvenile-like, incipient caudal rays evident. B. Yolk-sac larva, 5.3 mm TL. C. Dorsal view of B. D. Yolk-sac larva, 5.5 mm TL, gas bladder forming. E. Yolk-sac larva, 5.8 mm TL. (*A, Ryder, J. A., 1887: 503. B-D, Mansueti, R. J., 1958a: figs. 18–19. E, Pearson, J. C., 1940: fig. 12.*)

ventral surface between anus and end of urostyle (but this pigment highly variable and apparently disappearing under certain environmental circumstances); eye golden (AJL). As development proceeds pigment migrates or coalesces to form 3 conspicuous pigment areas characteristic of the species: a series of stellate chromatophores along posterior two-thirds of trunk and tail; a heavy concentration along dorsal peritoneal wall, on dorsolateral and ventrolateral wall of yolk, and along gut; and a heavy concentration around oil globule.[7] Ventral chromatophores intense at 5.2 mm.[151] At 5.5 to 5.8 mm (5 days) melanophores on lower jaw and in two rows along dorsal aspect of yolk sac to anus. At 5.8 to 6.5 mm (5 days) large melanophores on head and gill covers, orange chromatophores on upper caudal division at level of myomeres 20 to 23.[108] In a 6.0 mm specimen a large chromatophore on upper surface of gas bladder, and a more or less continuous line of pigment along ventral portion of body from opercle to point midway between anus and tip of tail. Eyes not pigmented at 4.4 mm; partially pigmented at 4.5 to 5.2 mm (2 days), appearing gray. At 5.5 *to 5.8 mm (5 days) eyes shiny* black with reddish tinge and densely pigmented with black, orange, and yellow pigment.[108]

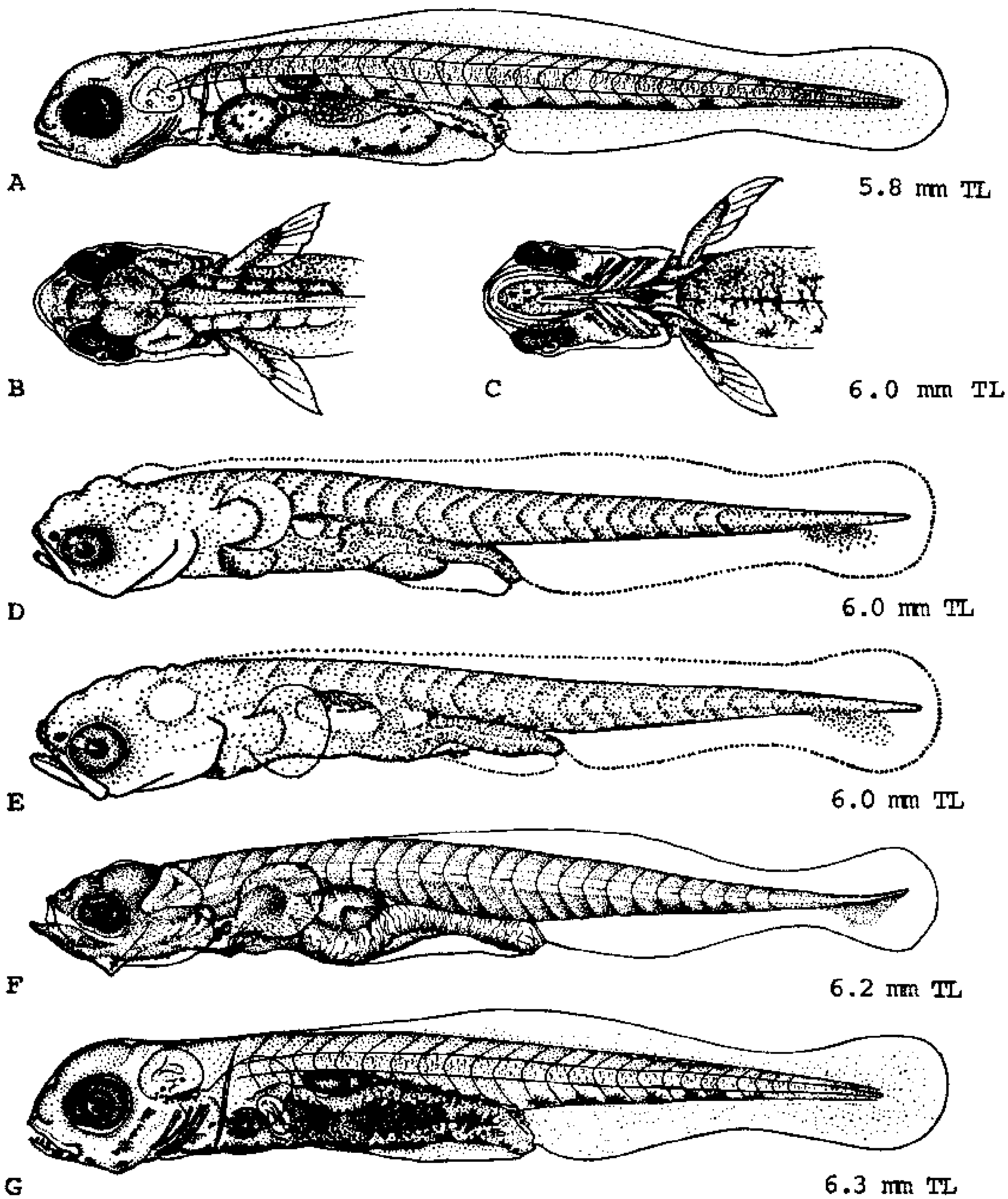


Fig. 54. *Morone saxatilis,* Striped bass. A. Yolk-sac larva, 5.8 mm TL. B. Detail of head of 6.0 mm TL specimen. C. Ventral view of B. D. Yolk-sac larva, 6.0 mm TL. E. Larva, 6.0 mm TL. F. Larva, 6.2 mm TL. G. Larva, 6.3 mm TL. (*A, G, Doroshev, S. I., 1970: fig. 2. B, C, Mansueti, R. J., 1958a: fig. 20. D, E, Pearson, J. C., 1940: fig. 13. F, Original illustration, Alice Jane Lippson.*)

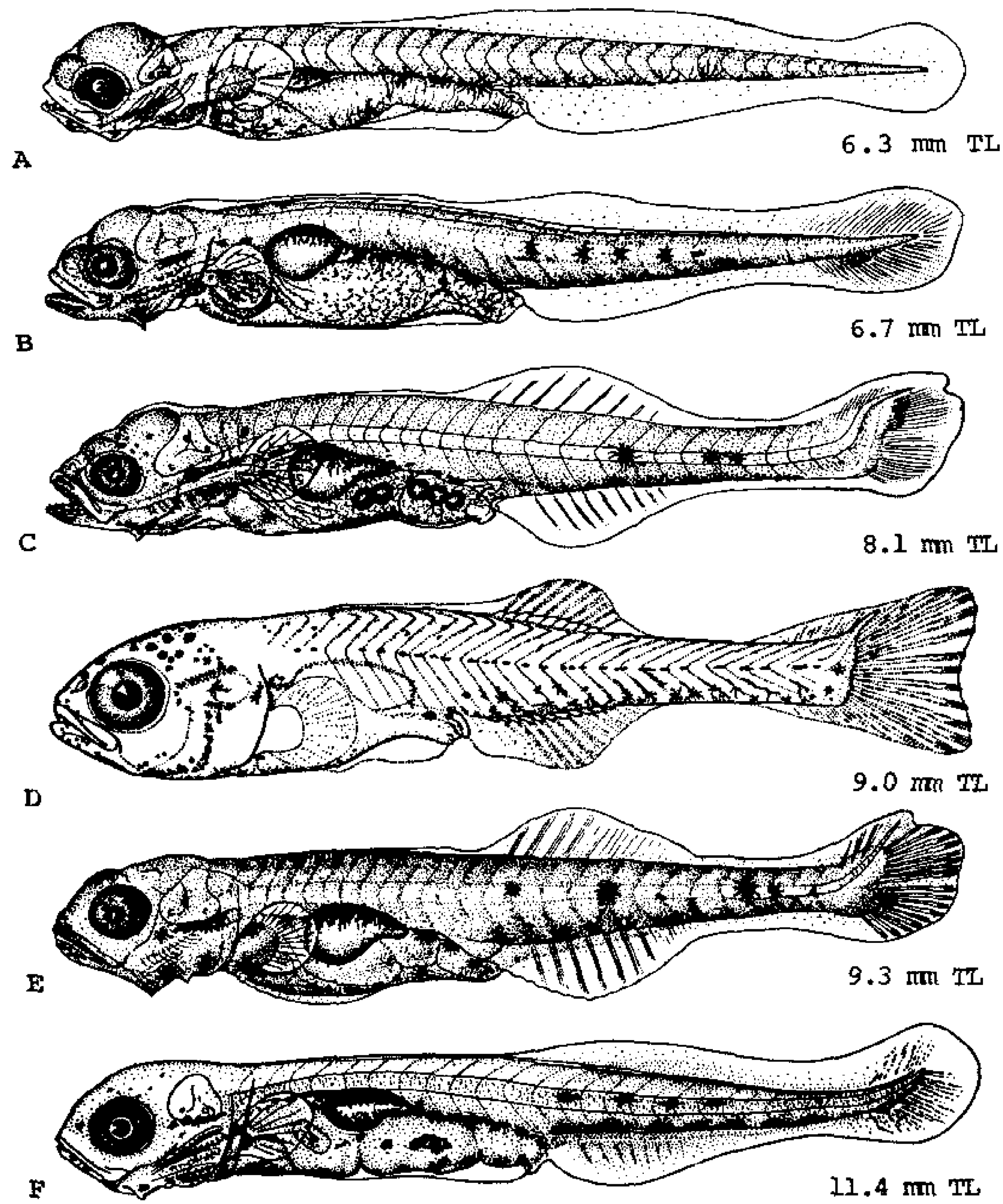


Fig. 55. *Morone saxatilis,* Striped bass. A. Larva, 6.3 mm TL, incipient rays in pectoral. B. Larva, 6.7 mm TL, incipient rays in caudal, lateral pigment developing. C. Larva, 8.1 mm TL, urostyle flexed, extended into caudal fin, incipient rays in dorsal and anal. D. Larva, 9.0 mm TL. E. Larva, 9.3 mm TL. F. Larva, 11.4 mm TL, but less advanced than previous stage. (*A-C, E, Mansueti, R. J., 1958a: figs. 21–24. D, Pearson, J. C., 1940: fig. 15. F, Doroshev, S. I., 1970: fig. 2.*)

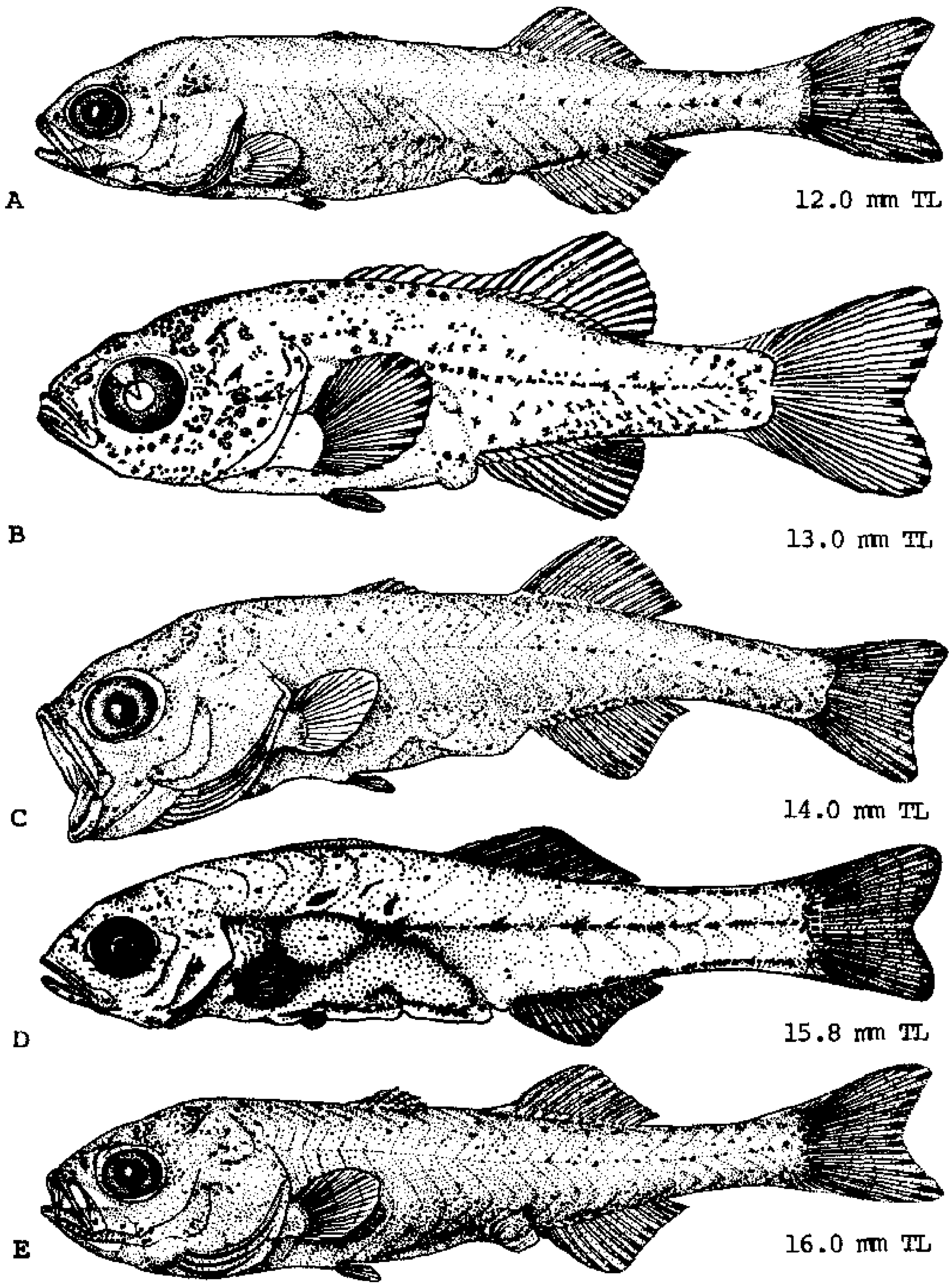


Fig. 56. *Morone saxatilis*, Striped bass. A. Larva, 12.0 mm TL. B. Larva, 13.0 mm TL. C. Larva, 14.0 mm TL, first dorsal fin with distinct rays. D. Larva, 15.8 mm TL, no rays evident in first dorsal. E. Larva, 16.0 mm TL. (*A, C, E, Mansueti, R. J., 1958a: figs. 25–27. B, Pearson, J. C., 1940: fig. 16. D, Doroshev, S. I., 1970: fig. 3.*)

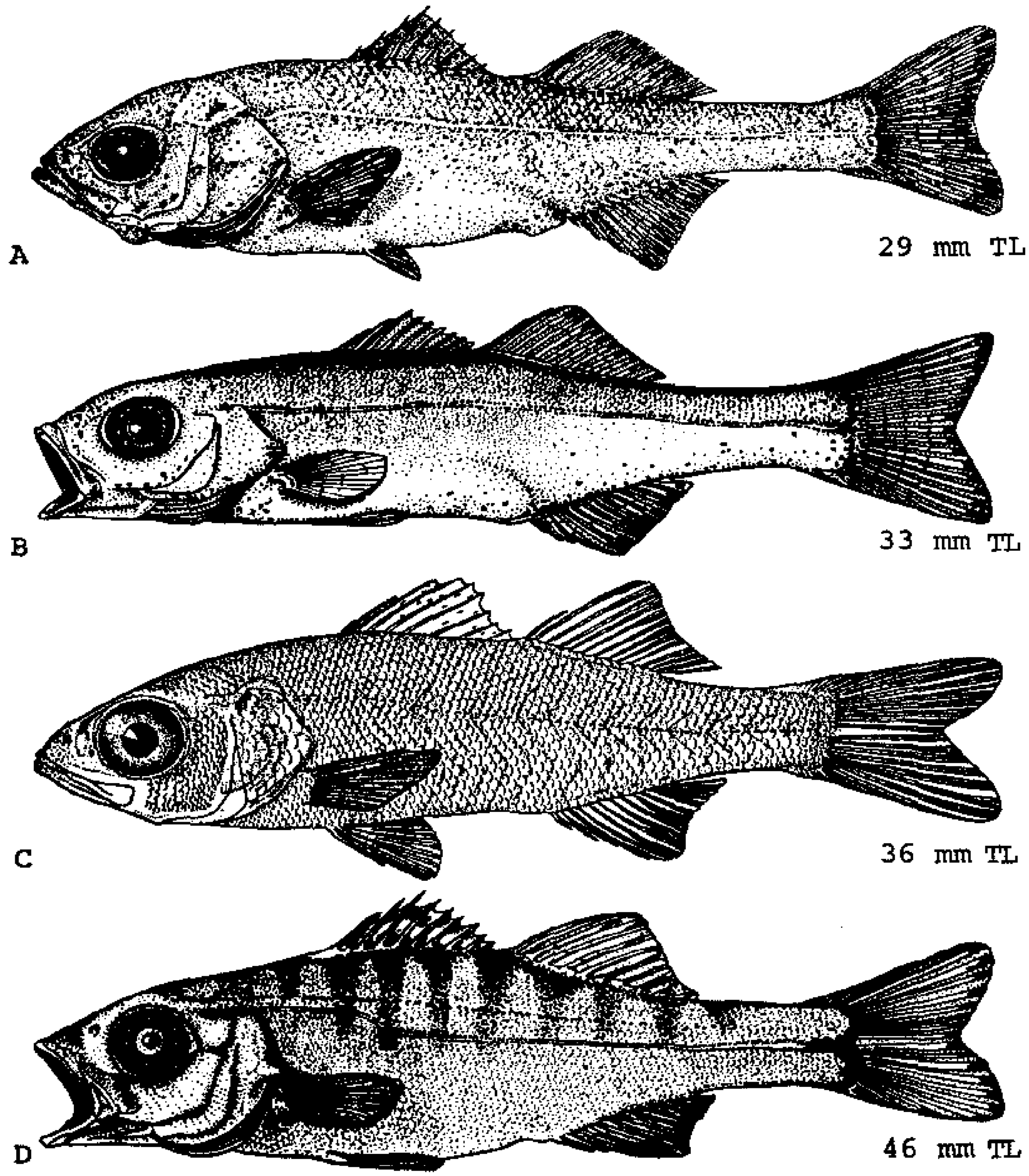


Fig. 57. *Morone saxatilis*, Striped bass. A. Larva or early juvenile, 29 mm TL. B. Larva or early juvenile, 33 mm TL. C. Juvenile, 36 mm TL. D. Juvenile, 46 mm, showing pattern of vertical bars typical of early juveniles. (*A, Mansueti, R. J., 1958a: fig. 28. B, D, Doroshev, S. I., 1970: fig. 3. C, Pearson, J. C., 1940: fig. 36.*)

LARVAE

Minimum length, 5.0 mm,[10] maximum length ca. 25[7] to 36 mm.[161]

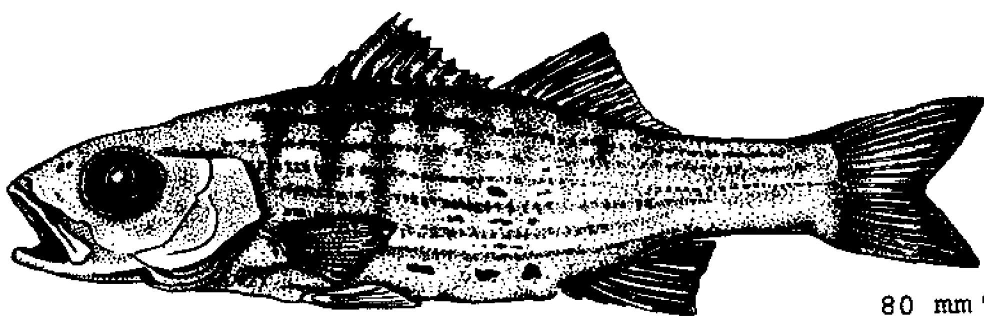
Total myomeres, 23 to 27, mean 25; preanal myomeres increase with length to 5.0 mm, stabilize at 11 to 13, mean 12; postanal myomeres 12 to 13, mean 13; myomeres no longer visible after ca. 13 mm. Vertebrae 12 + 13 = 25, and apparently developing from anterior to posterior.[7]

Average proportions expressed as percent average SL: Head length, at 7.0 to 7.5 mm TL, 23.2; at 25 to 26 mm TL, 31.4; at 29 to 30 mm TL, 31; greatest depth, at 7.0 to 7.5 mm TL, 20.9; at 25 to 26 mm TL, 24.5; at 29 to 30 mm TL, 22.8; distance from snout to anus, at 7.0 to 7.5 mm TL, 57.1; at 25 to 26 mm TL, 63.6; at 29 to 30 mm TL, 62.8; eye length, at 7.0 to 7.5 mm TL, 7.3; at 25 to 26 mm TL, 10.6; at 29 to 30 mm TL, 11.6.[7] Snout-vent length 54 to 59 percent TL.[10] Body depth fixed at

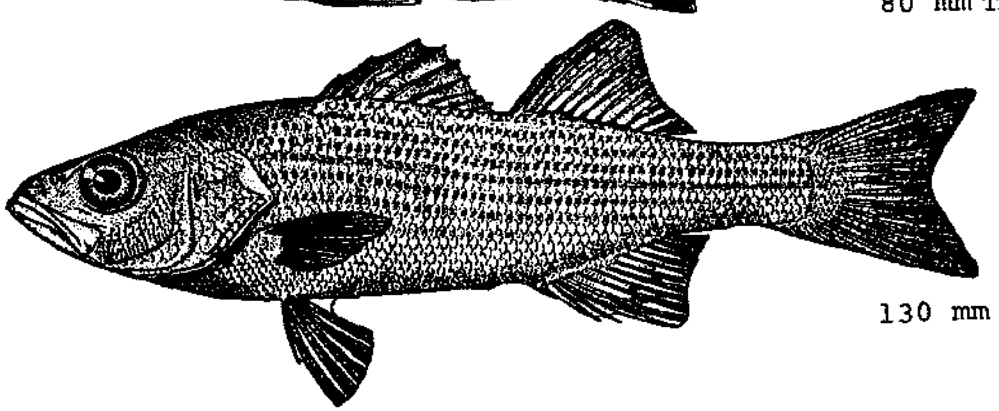
32 [131] to 36 mm.[151]

Body initially quite slender,[7] depth at caudal peduncle greatly increased by 8.1 mm, and greatest body depth increased by end of stage. At less than 35 mm dorsum not strongly arched.[50] Branchiostegal rays first evident at ca. 7.0 mm, full complement at 8.0 mm (with sequence of ossification apparently moving from upper to lower).[7] Early larval teeth slender, conical, and recurved; premaxillary teeth evident at ca. 8.0 mm; at ca. 12.0 mm teeth on both jaws biserial, those of inner rows slightly longer and directed backward. At sizes of 8.2 to 18.5 mm, mandibular teeth increase from 6 to 56, premaxillary teeth from 5 to 48.[7] Three preopercular spines in specimens 12 to 13 mm long; preopercle well serrated at 15 to 20 mm.[7,10] Dorsal finfold no longer extended forward to head after 6.2 mm; after ca. 8.1 mm greatly reduced; at 9.0 to 12.5 mm finfold clearly divided into three regions, lepidotrichia of caudal fin visible.[108,151] Preanal finfold lost at ca. 11 to 13 mm. Dorsal spines and ca. 1/3 soft dorsal rays evident at ca. 7.0 to 8.0 mm (although not evident in illustrations of these sizes); at 13.0 mm dorsal spines still rudimentary; [7] soft dorsal complete at 12 [108] to 20 mm, dorsal spines at ca. 24 mm.[7] Although Pearson maintained that the two dorsals are connected at sizes up to 13.0 mm,[151] Mansueti felt that they were never actually connected.[7] Anal fin first evident at ca. 7.0 mm; spines and rays at 9.0 mm; usually 2 anal spines at 10 to 15 mm; third spine derived from first soft ray at 15 to 25 mm; anal rays completed at ca. 20 mm,[7] spines at 12 to 20 mm,[62,88] but completion of anal fin variously estimated at 12 [108] to ca. 20 mm.[7,10] Caudal rounded or spatulate early in stage,[7] rays differentiated at 9.0 to 16 mm.[108] Pectoral buds first evident at ca. 5.0 mm, pectoral fins fan-shaped by end of stage, incipient rays evident at 6.0 mm, full complement (16 rays) not yet developed at 30 mm.[7] Pelvic buds evident at ca. 10 to 14 mm, rays fully developed at ca. 24 mm.[7,151] Urostyle oblique and projecting at ca. 8.0 to 10.0 mm.[10] Lateral line scales first evident at ca. 16 mm, series complete in some individuals at 20 mm, in all at 30 mm; [66] but initial appearance of scales (position on body not given) apparently variable. Pearson reports scales at 10 mm,[152] Mansueti at ca. 20 to 21 mm, but with imbrication at slightly smaller sizes.[7] Minimum length at completion of scale formation variously reported as ca. 25 mm,[7] 36 mm [151] and 46 mm.[108] Stomach well-developed by 13th day.[54] Gas bladder filled with air in 5 to 10% of individuals at time of beginning of active feeding, 1 to 3 days later in remaining larvae.[108]

Pigmentation: At ca. 7.5 mm melanophores along ventral part of body, over upper surface of air bladder and visceral mass; branching melanophores on side of head,



A 80 mm TL



B 130 mm TL

Fig. 58. *Morone saxatilis*, Striped bass. A. Juvenile, 80 mm TL, juvenile pattern of vertical bars still evident over developing adult pattern. B. Juvenile, 130 mm TL. *(A, Doroshev, S. I., 1970: fig. 3. B, Pearson, J. C., 1940: fig. 18.)*

lower jaw, and along lateral portion of anus. At sizes up to 10 mm yellow and orange chromatophores in eye, on head, and slightly posterior of anal base.[7] A 9.0 mm specimen described as above but also as having numerous large chromatophores on top of head and a broken line of pigment along mid-body from pectoral fin to base of tail;[151] also at this size described as having 7 or more melanophores along ventral edge of gut.[16] At 10 mm pigment generally more intense than in earlier stages. In larvae 10 to 22 mm long pigment on head, snout, above and below eyes, and on upper part of opercular flap; also along posterior midline of body dividing upper and lower halves of myomeres, along posteroventral keel of trunk, at base of anal fin, on abdomen, and on caudal fin. Become translucent or opaque at 10[7] to 16 mm.[108] Pigment variable through these sizes. A 13 mm specimen had mid-lateral row of chromatophores from pectoral fin to caudal base,[151] while in a 15 mm specimen this row of pigment extended forward only to the region of the anus. At 20 mm lateral pigment heavier, fins pigmented.[7] At 22 to 35 mm generally described as having pigment more or less uniform over body but with small concentrations of pigment along backbone, on head, and at fin bases, and with overall light gray color.[108] At ca. 25 mm body covered with small melanophores giving diffuse spotted effect; at ca. 29 mm fins heavily pigmented, at ca. 30 mm pigment more abundant on most of body and fins, less so on abdomen;[7] at ca. 31 mm reported to have broad transverse bluish bands.[87] A report of lateral stripes (presumably like those of the adult) in specimens ca. 12 to 13 mm long[21] has been questioned.[7]

JUVENILES

Minimum size described, 36.0 mm.

Body shape adult-like by 36.0 mm.[151] Average number of gill rakers in "young" fish, 24.48 in Chesapeake Bay,

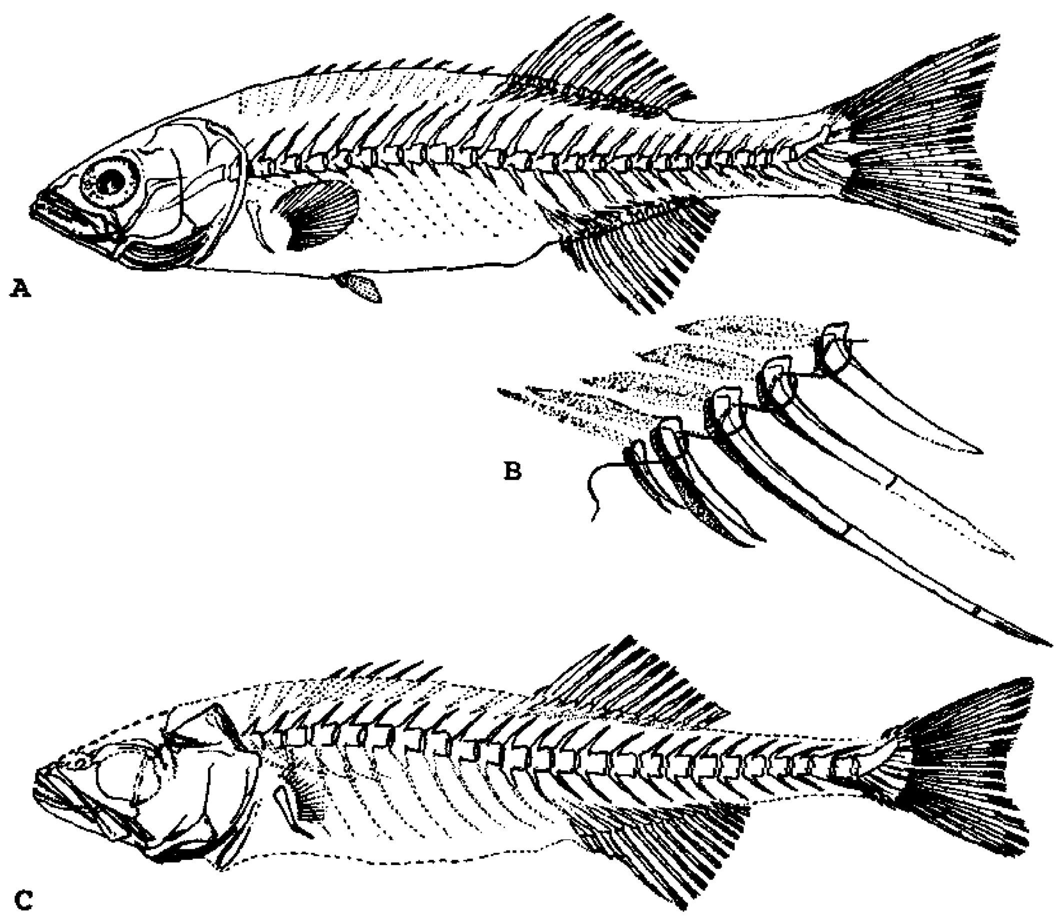


Fig. 59. *Morone saxatilis*, Striped bass. A. Larva, 12.5 mm, showing development of skeleton at this stage. B. The same specimen, showing details of anal spines and rays and their points of articulation with the radial elements. C. Larva, 10.0 mm TL, showing degree of skeletal ossification at this length. (*A, B, Mansueti, R. J., 1958a: fig. 4. C, Mansueti, R. J., 1958b: fig. 29.*)

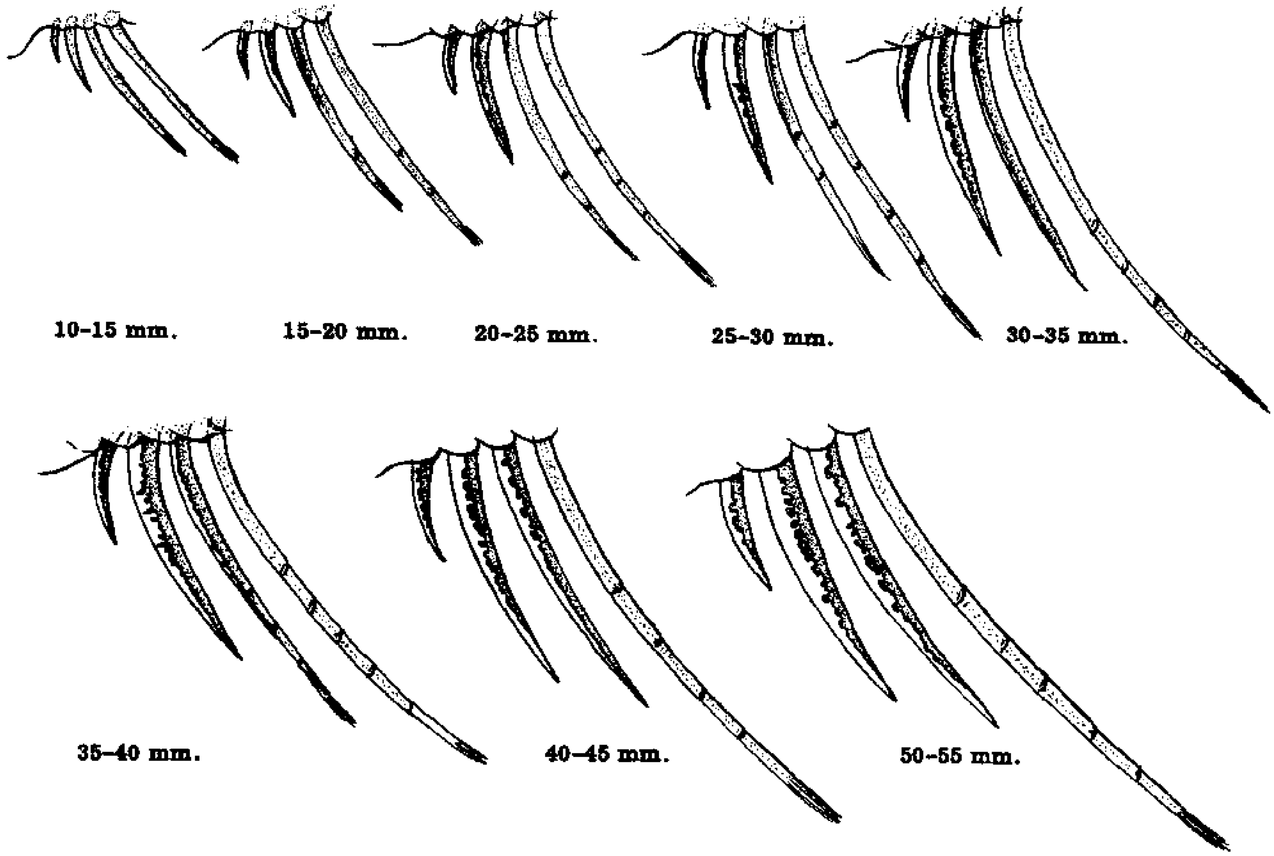


Fig. 60. *Morone saxatilis*, Striped bass. Development of third anal spine through a size range of 10 to 55 mm. (*Mansueti, R. J., 1958: fig. 2.*)

24.51 in Albemarle Sound, North Carolina.[7] First annulus at average length of 85.7 mm.[50] Differentiation of gonads between winter of first year and summer of second year at 130 to 150 mm FL.[137]

Pigmentation: At 36.0 mm small black dots over entire body, large chromatophores on top of head, ca. 9 oblique V-shaped marks along lateral line (possibly representing blood vessels).[151] At 46.0 mm (or 50 to 60 days) body silvery. At 50 to 80 mm, 6 to 10 poorly defined vertical stripes on sides of body and 5 to 6 well-developed longitudinal stripes above and below lateral line (although longitudinal lines may be lacking in specimens up to 70.0 mm long).[108,156] At 130 mm (ca. 1 year old) adult pattern of longitudinal stripes well-developed with faint tracings of vertical bars sometimes persisting, dorsal and caudal fins heavily stippled with fine dots.[151]

AGE AND SIZE AT MATURITY

Earliest females mature at end of 3rd year,[5,12,80] or beginning of fourth year [152,156] (although several 2 year old females captured in fall had enlarged ovaries and may have matured during the following spring [216]). Estimates are as follows: in 3rd year 18.2% mature; in 4th year 25 [152,156] to 94%; [160] in 5th year 75 to 100%; in 6th year 95 [152,156] to 98%; thereafter 100%.[67] Note, however, that the presence of large ova implies that maturity has been reached, but not necessarily that fish will spawn next season,[152] and some ova show signs of developing a year or so before they ripen.[99] Males mostly at 2 years,[15,25,35,142] some possibly when 1 year old [13,152] (males 11 months old may show slight milt discharge [137]); and probably all at 3 years.[181]

Minimum length at maturity, females ca. 432 mm,[68] males ca. 174 mm.[152]

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Polyprion americanus (Bloch and Schneider), Wreckfish

ADULTS

D. XI [1,2,12] to XII,[11] 11–12; [1,2,10,12] A. III, 8–9; [1,2,9,12] 9 + 17 + 9; [9] P. 17 [1,12]–18; [7] V. I, 5; [1,12] lateral line scales 90 [9]–96; [7] gill rakers on lower limb of first arch 15 (including rudiments); [7] branchiostegals 7; [7,9] vertebrae 13 + 13; pyloric caeca 70.[9]

Depth 2.6–3.5 times in TL [10] (2.5–3.0 times in SL [2]); eye 4.8 to 5.5 times in HL.[10]

Body deep,[7] compressed; [2,17] head very rough; a prominent ridge and strong spines on each gill cover, and a bony protuberance over eye and on nape; mouth large; lower jaw conspicuously projected; [2] gape to posterior margin of eye.[7] Broad bands of villiform teeth in jaws, on vomer, and palatines; three patches of teeth on tongue arranged in a triangle.[7,9] Scales roughened on their free edges; head, breast, opercles, and maxilla covered with scales [7] and scales extending onto bases of soft-rayed fins.[2] Dorsal fins continuous; pectoral fins almost directly above pelvics; [2,7,15] caudal fin truncate.[10]

Pigmentation: Generally grayish,[2] gray-blue, black,[9] blackish brown or brownish red [9] or with upper parts of head and back black, sides dark gray; venter grayish white,[8] or yellowish; [15] also described in life as fine steely blue with velvety plum-like bloom, lighter below; tip of lower jaw with dark patch. Dorsal and anal fins bluish black; pelvic fins with white rays, bluish black membranes, and whitish border; caudal fin with dark distal band and tendency to light outer edge. Iris golden and black.[5,8]

Maximum length: 2100 mm.[10]

DISTRIBUTION AND ECOLOGY

Range: In the western Atlantic, Grand Banks, Newfoundland to La Plata River, Argentina; in the eastern Atlantic, Norway to Cape of Good Hope including the Mediterranean and the Canary Islands; also the Indian Ocean and New Zealand.[2,4,7,8]

Area distribution: New Jersey.[6,11]

Habitat and movements: Adults—a typically solitary,[6] coastal,[4] bottom [2] species often found around wrecks; [3] also prone to gather under masses of floating wreckage [5] or seaweed; [15] occasionally run up rivers.[6] Maximum depth, 1000 meters.[15]

In Mediterranean Sea a general inshore movement has been observed during summer and fall.[18]

Larvae—no information.

Juveniles—pelagic,[12] swimming near surface, often in schools, and often under floating logs or wreckage.[2,3,6]

SPAWNING

Location: Unknown, except for fact that advanced eggs have been collected in the Straits of Messina.[13]

Season: In the Mediterranean, January to April; [15] also eggs in Straits of Messina in July, and a female in advanced development in mid-October.[15]

EGGS

Location: Pelagic.[13]

Ripe eggs (advanced but not perfectly mature): Diameter 1.4 mm, yolk 1.28–1.30 mm, capsule more or less smooth, yolk superficially granular.[13]

Fertilized eggs: Spherical, diameter 1.60–1.64 mm, chorion granular, yolk diameter 1.20–1.28 mm, yolk granular and with 1 large and 1–8 small oil globules (which apparently coalesce as development proceeds).[13]

EGG DEVELOPMENT

Development of field-collected eggs at unspecified temperature:

Day 1, 0930 hours.	Embryo a little less than halfway around yolk, otic *vesicles formed*, blastopore closing, ca. 10 somites.
Day 1, 1500 hours.	Embryo ca. 2/3 around yolk, otoliths formed, 14 somites, 10 small stellate chromatophores on yolk.
Day 2, 900 hours.	20–23 somites, pigment developing on head and trunk.
Day 2, 1500 hours.	Hatching.[13]

YOLK-SAC LARVAE

Hatching length, 3.72 mm TL.[13]

Myomeres 12 + 13.[13]

At hatching body compressed; head not flexed; mouth not open; yolk sac large, but not extended forward beyond posterior margin of eye; dorsal finfold forward to cephalic region; gut straight.[13]

Pigmentation: Eye unpigmented; a heavy streak of pig-

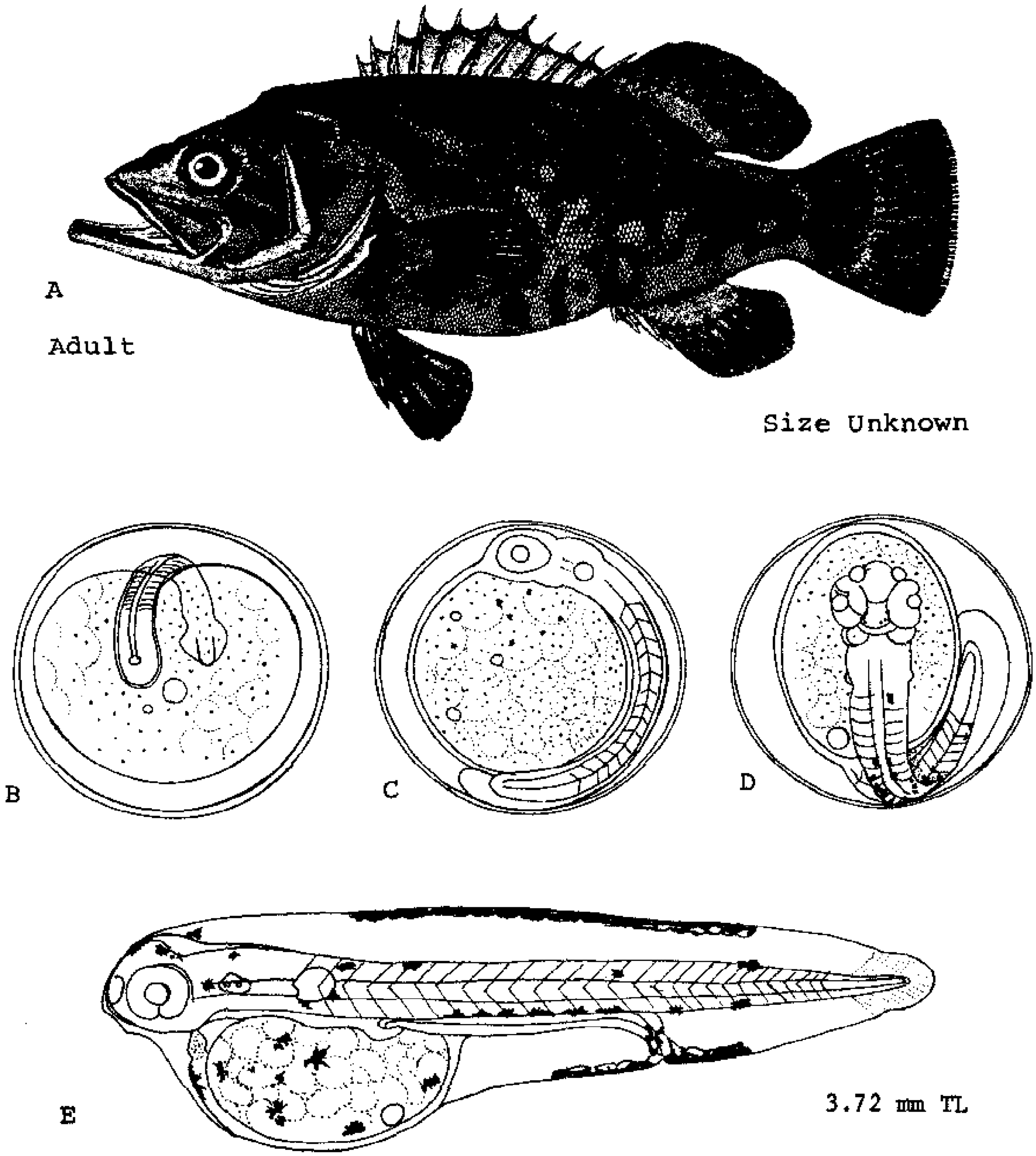

Fig. 61. ***Polyprion americanus***, Wreckfish. A. Adult, size unknown. B-D. Development of eggs. B. Optic vesicles forming, ca. 10 somites. C. Pigment developing on yolk. D. Advanced embryo, yolk reduced, pigment developing on head and body. E. Yolk-sac larva, 3.72 mm TL. *(A, Le Gall, J., 1932: Unnumbered, after Smitt, 1892. B-E, Spartà, A., 1939: figs. 1–4, Tamiko Karr, delineator.)*

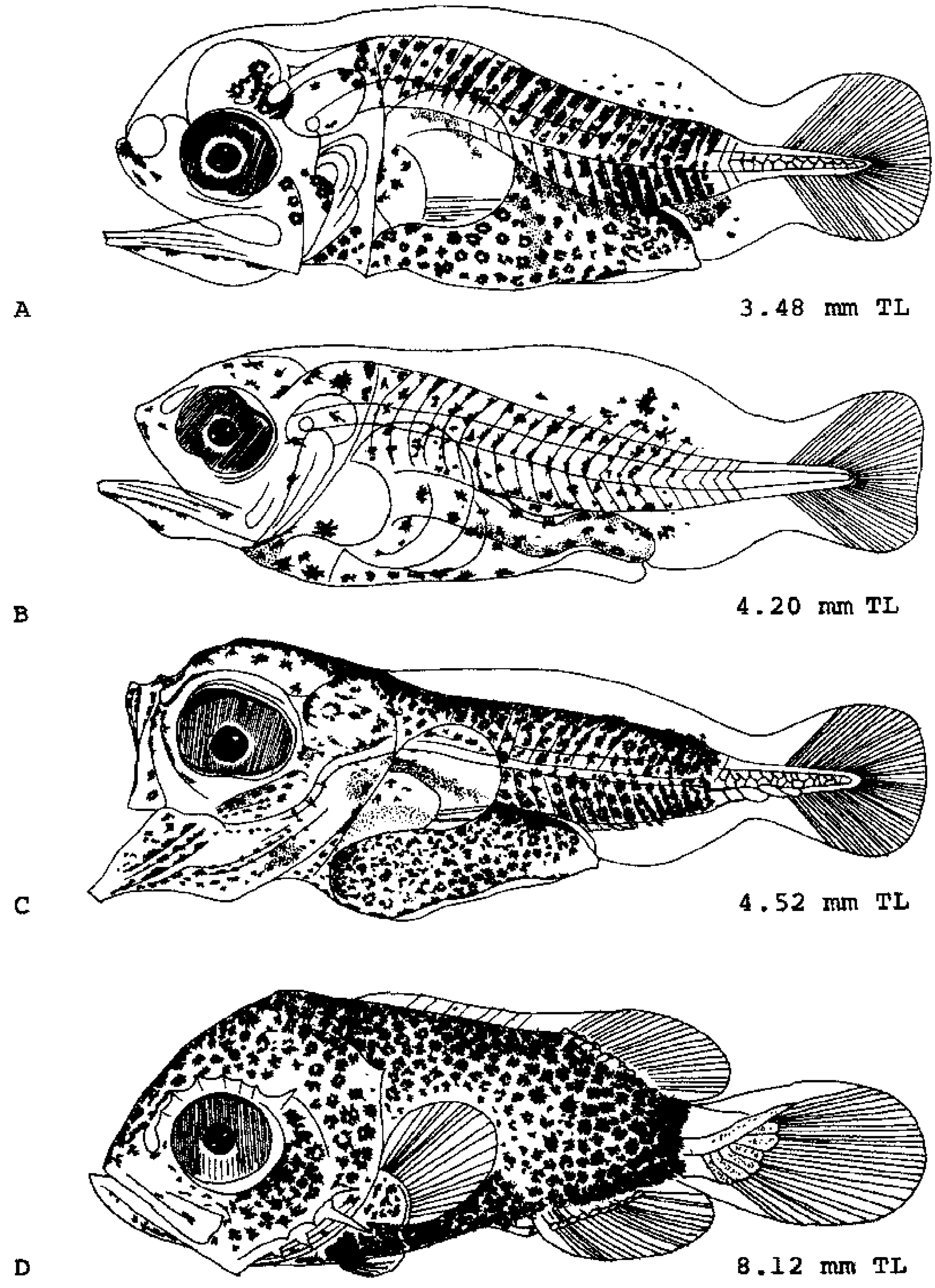

Fig. 62. *Polyprion americanus*, Wreckfish. A. Larva, 3.48 mm TL, pigment extended onto dorsal and anal finfolds. B. 4.20 mm TL, finfold pigment at maximum development. C. 4.52 mm TL, head spination developing. D. 8.12 mm TL, preopercular spines well-developed, urostyle oblique. (*A-D, Spartà, A., 1939: figs. 5–8, Tamiko Karr, delineator.*)

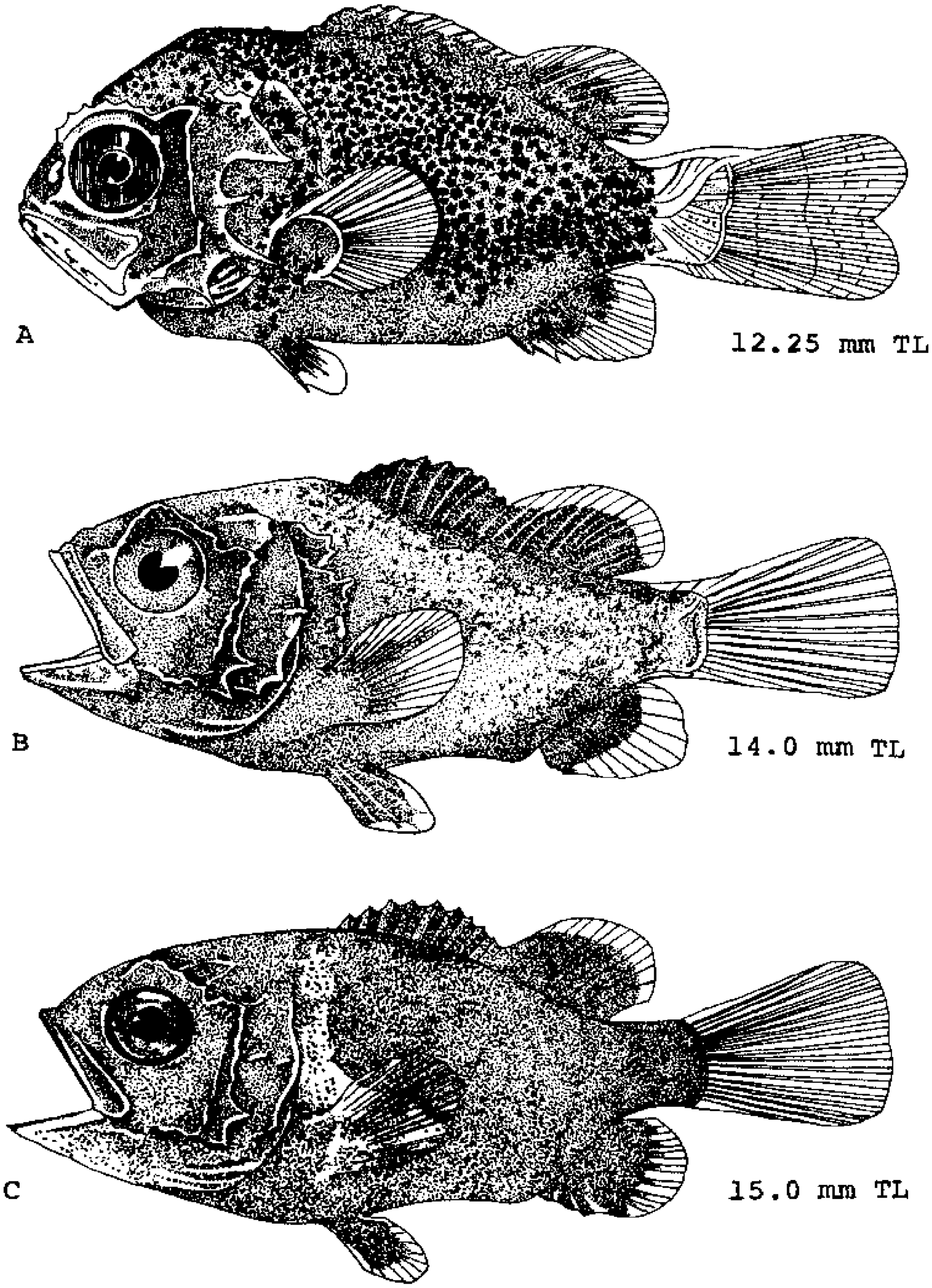

Fig. 63. *Polyprion americanus*, Wreckfish. A. Juvenile, 12.25 mm TL. B. Juvenile, 14.0 mm TL, head spination reduced. C. Juvenile, 15.0 mm TL. (*A, Spartà, A., 1939: fig. 9, Tamiko Karr, delineator. B, Emery, C., 1886: fig. 14, Tamiko Karr, delineator. C, Bertolini, F., 1933: pl. 21, Tamiko Karr, delineator.*)

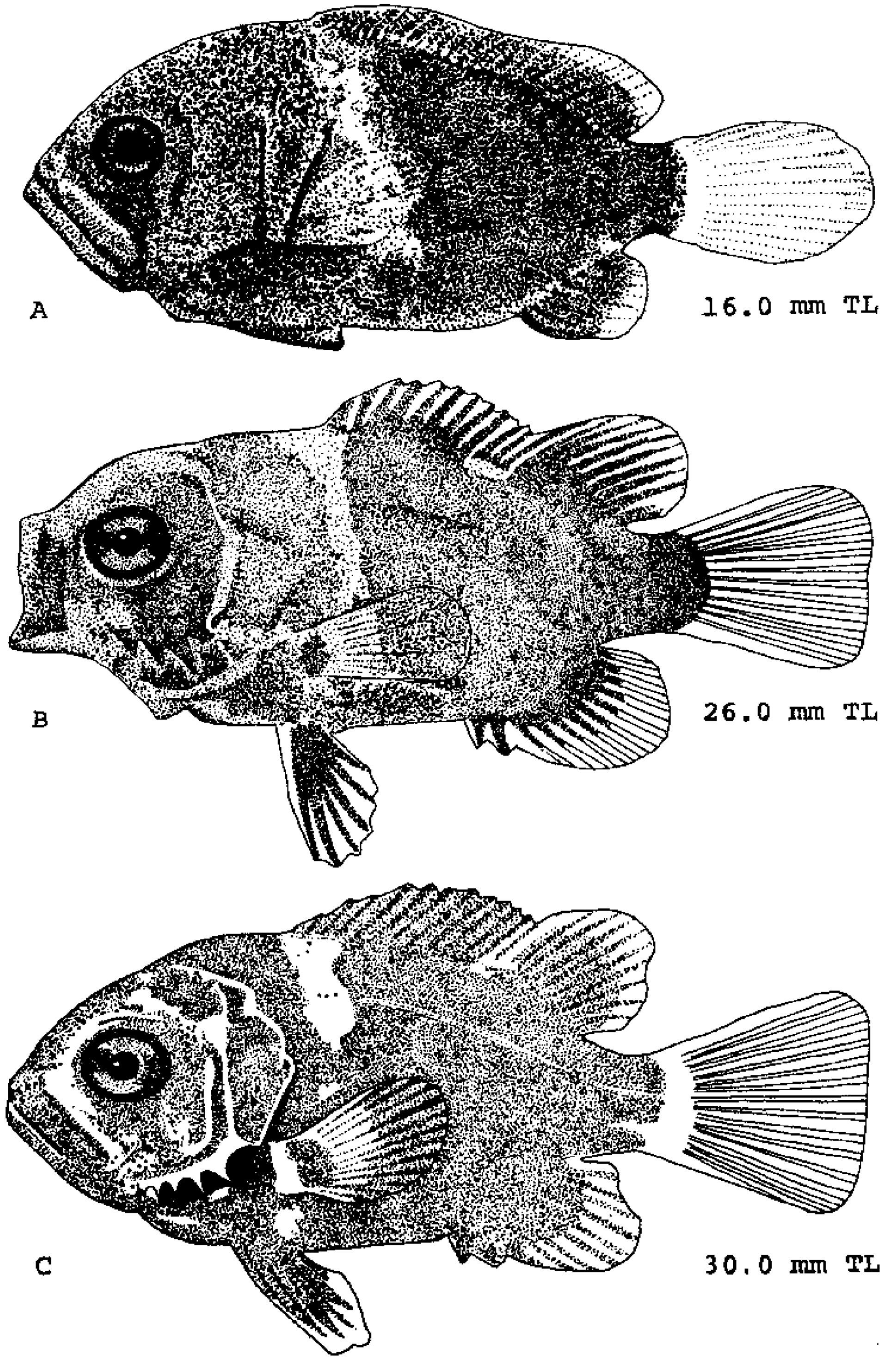

Fig. 64. *Polyprion americanus*, Wreckfish. A. Juvenile, 16.0 mm TL. B. Juvenile, 26.0 mm TL. C. Juvenile, 30.0 mm TL. (*A, Bertolini, F., 1933: pl. 21, Joan Ellis, delineator. B, C, Bertolini, F., 1933: pl. 21, Tamiko Karr, delineator.*)

ment along margin of dorsal and anal finfolds; a pigment streak along ventral ridge of body above gut; two patches of melanophores ventrally on body beyond anus; several pigment patches along length of dorsal ridge; scattered chromatophores on yolk and head.[13]

LARVAE

Size range described, 3.48–8.12 mm TL.[13]

Total myomeres 24–25.[13]

Mouth extended to posterior margin of eye at 4.2 mm; eye ovoid throughout stage; branchial and Meckel's cartilages formed at 4.2 mm; at 4.2 mm 3 spines on preopercle, at 8.12 mm spines on both preopercle and opercle; at 8.12 mm supraorbital crest developed. Finfold lost, notochord flexed at 8.12 mm. First evidence of dorsal, anal and caudal fin at 4.2 mm; pectorals rounded and with incipient rays at 4.25 mm; pelvics first evident at 8.12 mm.[13]

Pigmentation: In a laboratory-reared specimen 4.12 mm long, pigment no longer visible along edge of finfold;

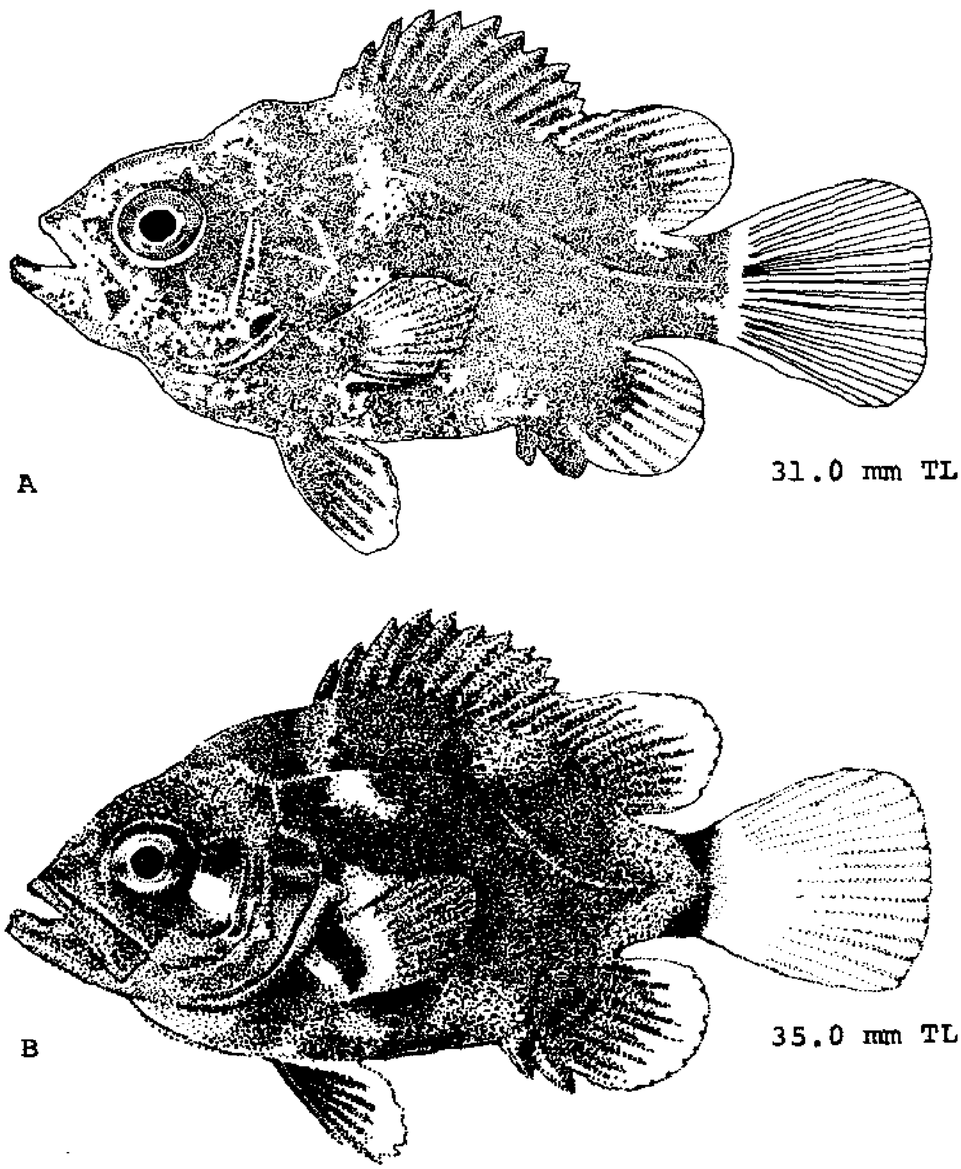

Fig. 65. *Polyprion americanus*, Wreckfish. A. Juvenile, 31.0 mm TL. B. Juvenile, 35.0 mm TL. (*A, Bertolini, F., 1933: pl. 21, Tamiko Karr, delineator. B, Bertolini, F., 1933: pl. 21, Joan Ellis, delineator.*)

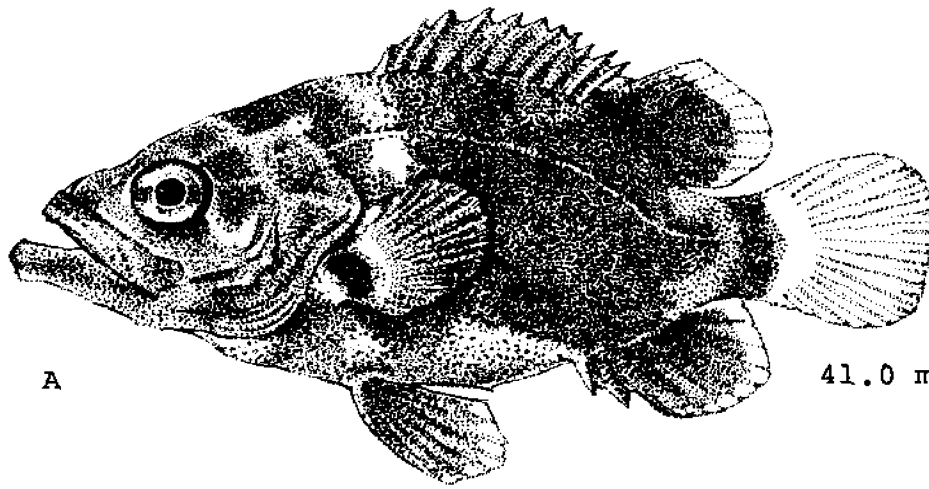

Fig. 66. *Polyprion americanus*, Wreckfish. A. Juvenille, 41.0 mm TL. (*A, Bertolini, F., 1933: pl. 21, Joan Ellis, delineator.*)

few large, stellate melanophores in lower half of dorsal finfold above posterior part of gut, and a similar large melanophore on ventral finfold near anus; stellate melanophores on trunk, along ventral edge of body, and on gut; a single melanophore on lower edge of mandible; pigment entirely lacking on posterior part of body; eye pigmented and with metallic reflections. In a field-collected specimen 3.48 mm long pigment more dense on body, less dense on finfolds. At 8.12 mm pigment on head increased, and dense pigment developing at bases of dorsal, anal, pectoral, and developing pelvic fins.[13]

JUVENILES

Minimum size described, 12.0 mm.[1]

At 12 mm, depth 3 times in length, about equal to HL.[1]

At lengths up to 34 mm dorsal profile of head rounded; at 41 mm head shape typically adult-like. Mandible protuberant at 30 mm.[1] At 14 mm 5 upper and 4 lower preopercular spines;[14] preopercular spines reduced at 25–30 mm. At 12 mm pectoral fins fan-shaped.[1] Caudal fin rounded throughout stage.[10] Developing spines serrated, but serrations lost with continued growth.[7] Anus initially somewhat posterior to midpoint of body, but shifted toward mid-body as development proceeds.[1]

Pigmentation: At ca. 12 mm body no longer transparent, brown throughout; but with an incomplete transverse yellowish stripe at beginning of dorsal fin; dorsal, pectoral, and outer edges of soft dorsal and anal fins colorless; otherwise fins densely pigmented.[1,9] A 14 mm specimen described as brown tinted with yellow.[14] Between 25 and 30 mm color changes from brown to gray-brown. At 26 mm vertical light band on anterior part of body well-developed, conspicuous. In later stages (up to at least 41 mm) this band broken into elongate spots and similar spots developed on head, back, and lower sides of body.[1] A specimen 150 mm long is described as mottled with gray on a cream background.[6] Young described as mottled with gray and cream[2] and with scattered irregular white and smaller black blotches.[15]

AGE AND SIZE AT MATURITY

No information.

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Lobotes surinamensis

tripletails
Lobotidae

FAMILY LOBOTIDAE

These fishes are found primarily in tropical marine waters, although east Indian members of the genus *Datnoides* are recorded from both brackish and freshwater. The family contains two genera and about four species.

Tripletails lack teeth on the palatines and vomer; the caudal fin is rounded and the posterior ends of the anal and second dorsal fins are expanded into distinct lobes, giving the fish the appearance of having a three-lobed tail.

In the regional species, *Lobotes surinamensis*, the eggs are presumably larger than 1.0 mm in diameter. Early larvae are unknown. In advanced larvae there are conspicuous preopercular spines and a small cranial crest, and the anus opens at a point almost two-thirds the distance to the tip of the tail. The juveniles frequently camouflage themselves by turning sideways and floating like leaves.

Lobotes surinamensis (Bloch), Tripletail

ADULTS

D. XI [37] to XIII,[38] 15–16; [15,33,37] A. III,[15] 10 [38]–12; [12] P. I, 15; V. I, 5; [25] scales variously described as 48,[12] 43–45,[37] or 37–45 on lateral line to caudal base plus 10 more on caudal base; [39] gill rakers on first arch 13 [29]–15 [37] + 5–6; vertebrae 12 + 12; [38] branchiostegals 6; pyloric caeca 3.[35]

Proportions as times in TL: Head 2.8 [35]–2.9; [1] depth 2.0 [35]–2.05.[1] As times in HL: eye 6.5, snout 4.1, maxillary 2.8, mandible 1.9, interorbital 3.5.[35]

Body deep, compressed; back elevated; anterior profile concave over eyes; head moderate [1] to large; [38] snout tapering; mouth oblique, the lower jaw projecting; gape to middle of eye; teeth in jaws small, pointed,[1] in narrow villiform bands with a row of larger, conical, posteriorly directed teeth anteriorly; [35] no teeth on vomer or palatines; [9] preopercular margin strongly serrate, the serrae at the angle much enlarged.

Scales extended more or less onto bases of all soft fins; scales moderate size, weakly ctenoid.[35] Pelvic fins thoracic [38] and extending to vent; [1] caudal fin rounded; [38] soft dorsal and anal fin opposite, both rounded; pectoral fins rounded.[38]

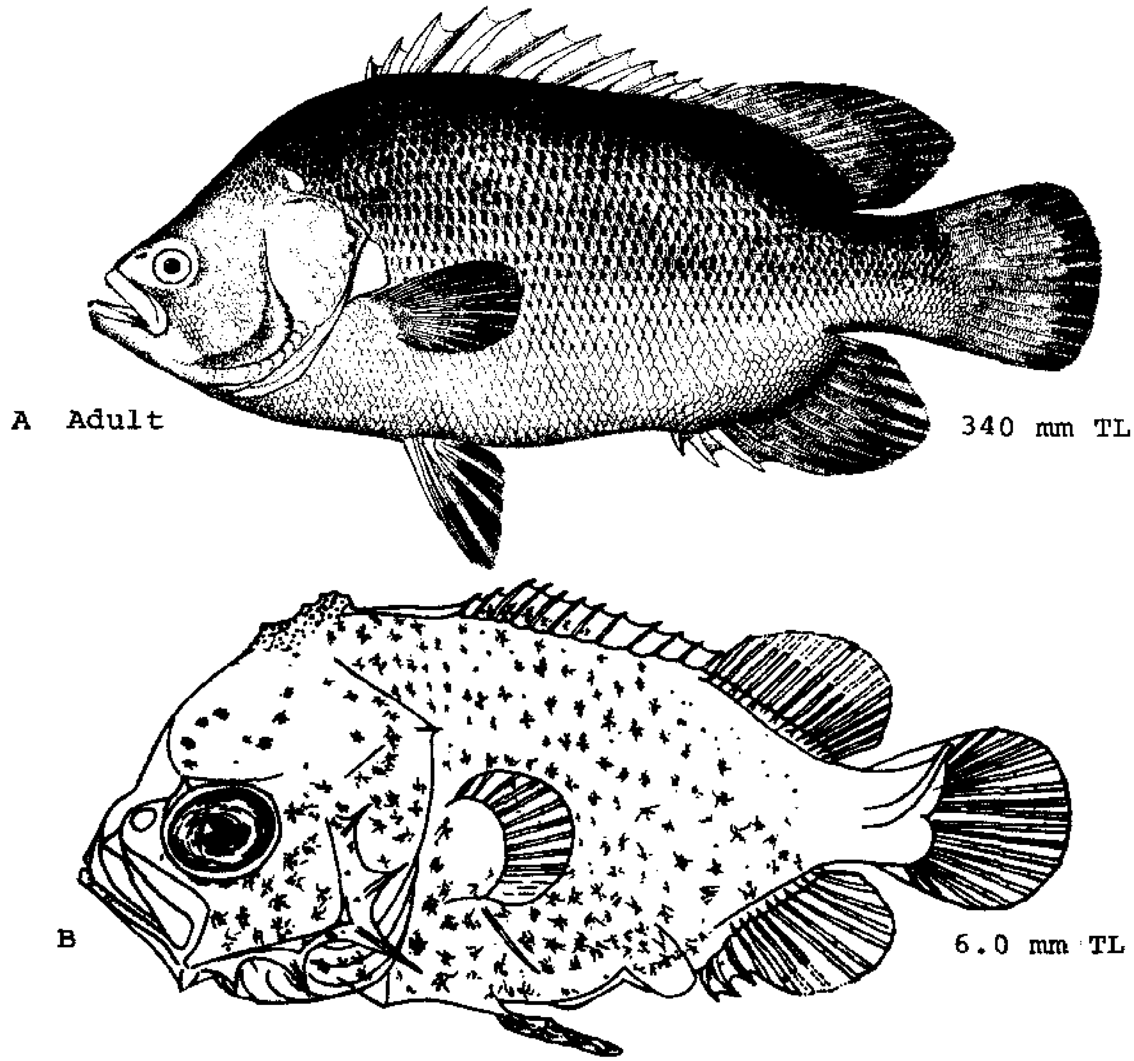

Fig. 67. *Lobotes surinamensis*, Tripletail. A. Adult, 340 mm TL. B. Larva, 6.0 mm TL. (*A, Goode, G. B.*, et al., *1884: pl. 175. B, Imai, S., 1958: pl. 21.*)

Pigmentation: Dull black above; silvery gray on sides and below; sides sometimes with small yellowish blotches; fins black or dusky, sometimes with yellowish blotches. Body more or less mottled up to about 610 mm. Specimens also described as brownish black with darker blotches below dorsal and anal fins; pectoral fins gray; caudal fin yellowish; soft dorsal and anal black-edged; other fins brownish to blackish, but this description may be based on juveniles. Adult fish may display nuptial colors. Generally bronze and green on sides, lighter below; area around jaws and gills yellowish; caudal dark blue-green; dorsal and anal pinkish green and lighter than caudal; pectorals yellowish; predorsal area marked with peacock color; scales on back and sides with deep bronze-green centers and blue margins.[1,16,23,35]

Maximum length: 1067 mm.[16]

DISTRIBUTION AND ECOLOGY

Range: Circumtropical; in the western Atlantic, Cape Cod, Massachusetts, to Argentina including Bermuda and the West Indies; in the eastern Atlantic the coast of Africa, the Mediterranean and St. Helena;[1,5,9,19,20] and in the Indo-Pacific[39] from Korea to southern Australia.[41]

Area distribution: Coastal waters of New Jersey;[20,25,34] Delaware Bay;[33] lower Chesapeake Bay, Virginia.[1]

Habitat and movements: Adults (although some of the following information may be based on juveniles)—in

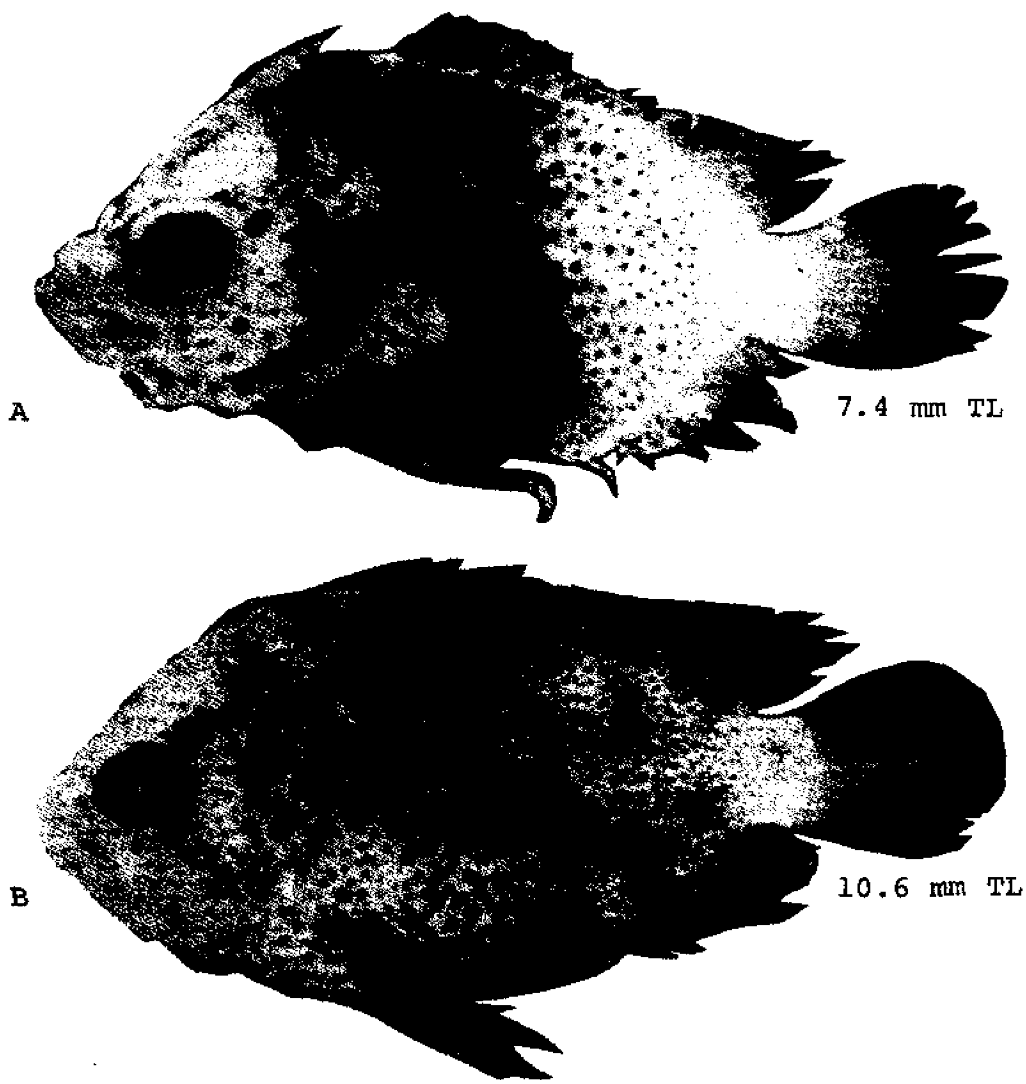

Fig. 68. *Lobotes surinamensis*, Tripletail. A. Juvenile, 7.4 mm TL. B. Juvenile, 10.6 mm TL. (*A, B, Senta, T., 1958: pl. 62.*)

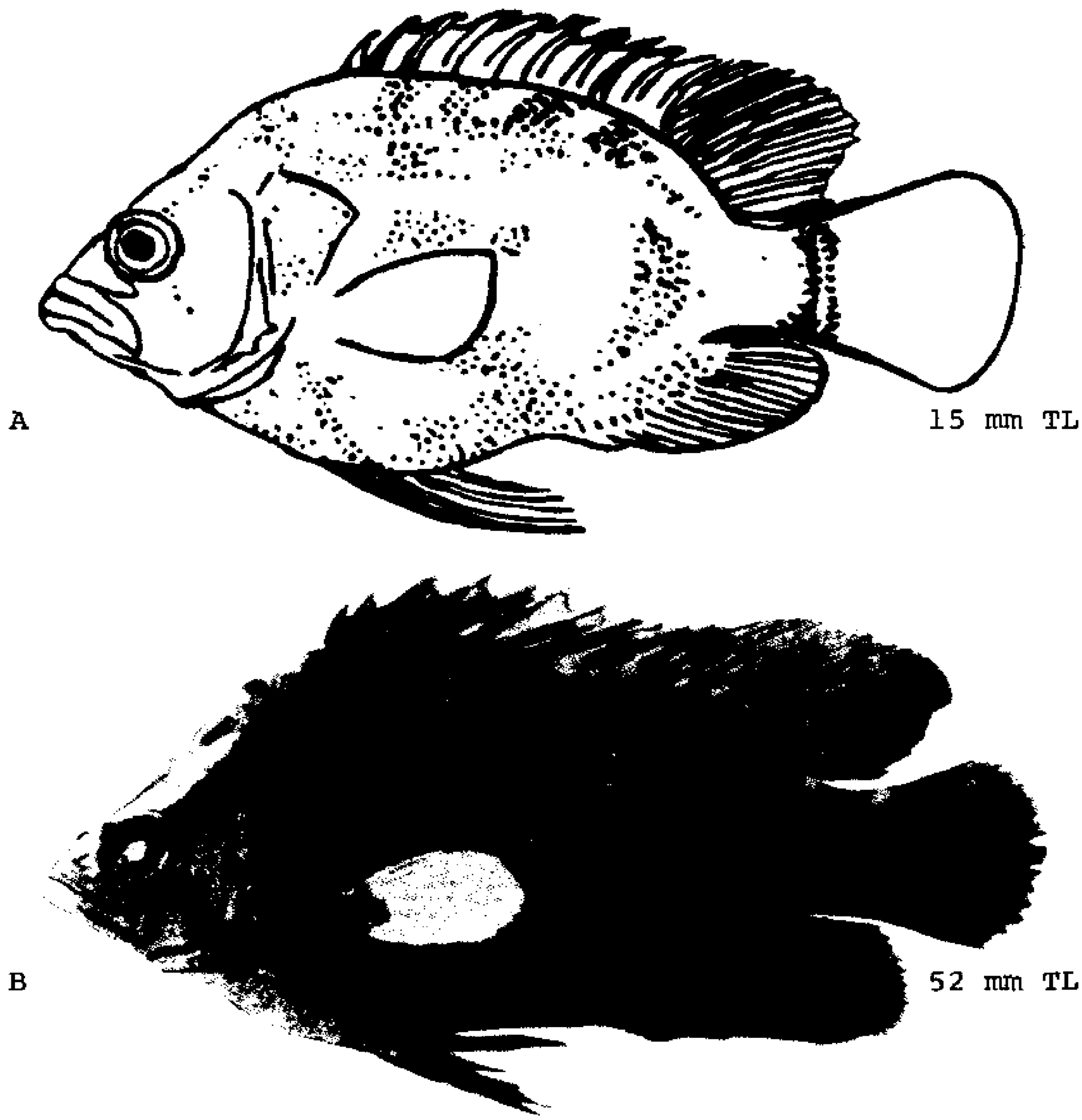

Fig. 69. *Lobotes surinamensis*, Tripletail. A. Juvenile, 15 mm TL. B. Juvenile, 52 mm TL. (*A, B, Gudger, E. W., 1931: figs. 3–4.*)

coastal areas frequently in shallow water around wrecks, buoys, boats, beacons, pilings, flotsam, jetties, and sometimes inshore under fallen trees and brush;[13,28] seek shade;[19] sometimes in surf washing over wrecks;[6,16] in inshore areas in bays,[23] harbors,[22] passes,[13] rivers,[20,37] and at mouths of smaller freshwater streams.[16] Over bottoms of sand, rock, or coral.[10,19] Frequently lie on sides on surface, sometimes at 45° angle with head downward and tail up.[3,8,16] Apparently attracted to lights at night.[6] Minimum depth 610 to 915 mm (but usually about 1 m below surface),[36] maximum depth 46 m.[19] Recorded over water up to 1573 m deep.[31] Minimum recorded salinity, 20 ppt[6] (although also recorded from mouths of smaller freshwater streams[16]). Maximum distance out ca. 275 km.[31]

Inshore in South Carolina spring through fall,[12] in Georgia June to October 15,[16] and on the Gulf coast April to October.[19] North to New York and New England in August, September, October, and December[24,30] (although Merriner and Foster suggest a northerly transport or migration with increasing temperatures, and a southern movement during fall and winter[43]).

Larvae—no information.

Juveniles—very small specimens inshore;[4,7,18] sometimes in harbors among algae; [19,22] also in or under clumps of floating sargassum weed.[9,17,41] Specimens up to ca. 330 mm long float at surface,[16] sometimes on their sides mimicking mangrove leaves.[9,11] Specimens 15–25 mm long in salinities of 10.0–19.9 ppt,[40] specimens ca. 165 mm in very nearly freshwater.[32,35] Young float great distances in sargassum weed [20] and have been seen in schools some distance offshore apparently migrating.[19]

SPAWNING

Location: Probably inshore.[43]

Season: In Texas with developed eggs in May, June,[18] and July,[44] spawning in late June, July, and August; in Mississippi large eggs in July and August; in Florida white roe in mid-summer; [19] in Georgia and North Carolina in August.[8,16]

Fecundity unknown.

EGGS

Ovarian eggs: Eggs ca. 1.0 mm in diameter were probably not quite ripe; eggs of various sizes occur in the ovaries simultaneously.[16]

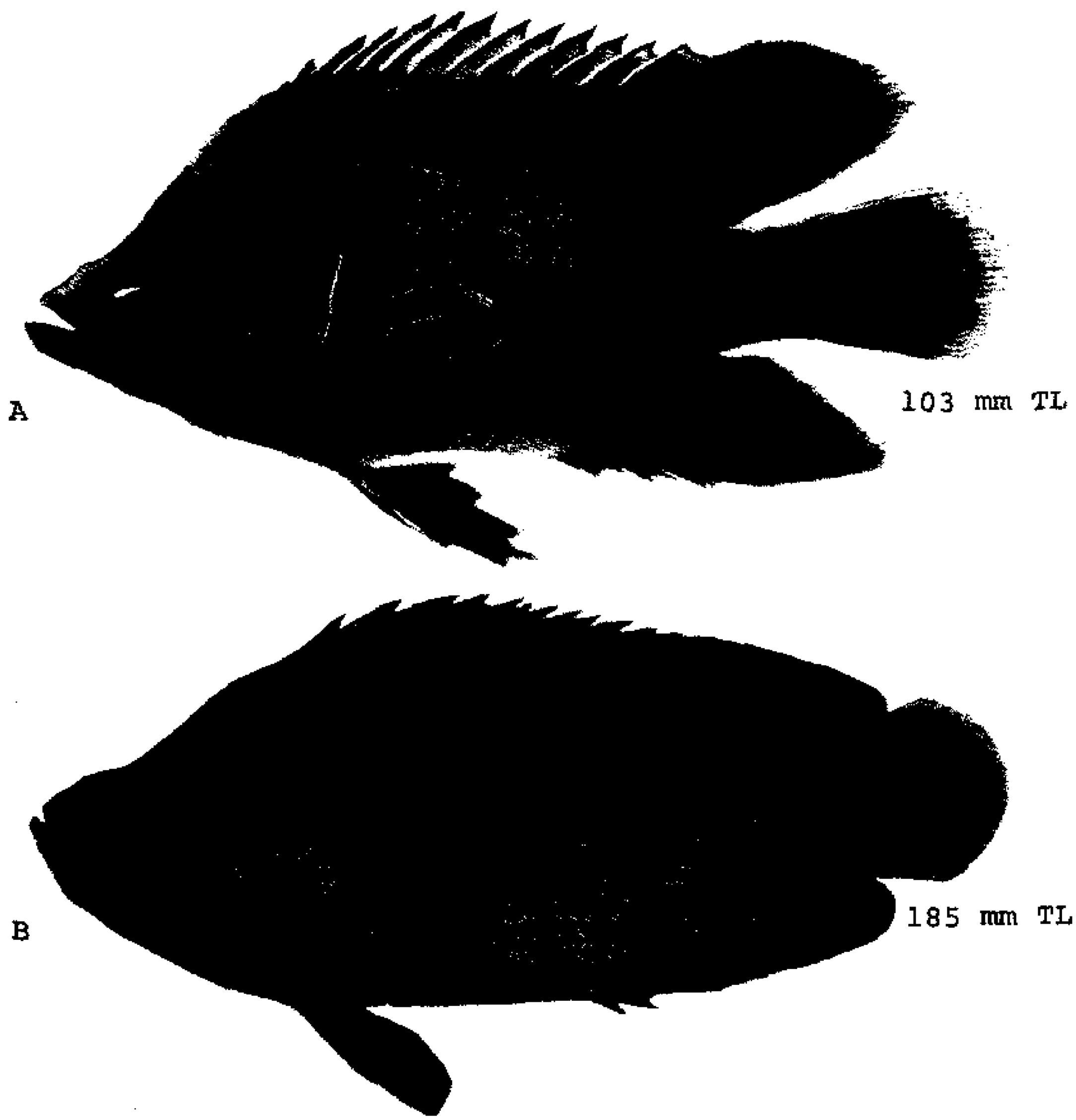

Fig. 70. *Lobotes surinamensis*, Tripletail. A. Juvenile, 103 mm TL. B. Juvenile, 185 mm TL. (*A, Böhlke, J. E., and C. C. G. Chaplin, 1968: 302 © Academy of Natural Sciences of Philadelphia. Used with permission of authors and publishers. B, Gudger, E. W., 1931: fig. 5.*)

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

Size range described, 6.0 [15]–7.4 mm.[14]

C. 9+9.[15]

At 6.0 mm TL (SL 5.3 mm) length to anus 74% SL, HL 40% SL, D. 47% SL, eye 21% HL.[15] At 7.4 mm TL (SL 5.6 mm) HL 46% SL, D. 59% SL.[14]

At 6.0 mm body laterally compressed; 5 conspicuous spines on the preopercle; a small cranial crest; premaxillary with 26 fine teeth; a remnant of predorsal and preanal finfolds; pelvic fins forming, but incomplete; urostyle oblique.[15]

Pigmentation: At 6.0 mm stellate chromatophores generally distributed on head and body (except caudal peduncle).[15] At 7.4 mm head and body pigment increased, spinous dorsal, anal, and pelvic fins with scattered chromatophores.[14]

JUVENILES

Minimum size described, 10.6 mm TL.[14]

Gill rakers 5–1–13; scales 55; [36] maxillary extended to vertical from posterior margin of pupil.[36]

At 10.6 mm TL (SL 8.3 mm) HL 43% SL, depth 57% SL.[14] Proportions as percent SL (based on two specimens of 120 and 263 mm SL): Head 33.3–34.1, depth 47.5–52.2, eye 4.1–6.2.[36]

Pigmentation: Body darker above than below; body grayish, brownish, greenish, yellow, yellow and tan, yellow and black, or bronze and blackish silver; [2,9,14,36] sometimes resembles yellowed leaves [20] and with yellowish and grayish blotches; fins same color as body except pectorals which are whitish and translucent; caudal fin with broad light marginal band; dorsal and anal fins narrowly marked with lighter; 2 narrow streaks on top of head extending to nape, another from posterior margin of eye to nape, and one from posterior margin of eye to lower angle of preopercle.[14]

In very small specimens brownish pigment tends to be concentrated in scale centers forming ill defined crossbars and narrow longitudinal streaks; anal sometimes distinctly ocellated.[14]

At 10.6 mm melanophores developed on caudal peduncle; pigment on head, opercle, and body increased; upper posterior part of eye with dark band.[14] At 15.0 mm pectoral and caudal fins entirely white.[16] At 18 mm soft dorsal fin tipped with pinkish, remainder of fin gray with pinkish tint toward base; caudal fin with wide translucent terminal band; snout pale. At 33 mm dull grayish green; all fins except pectorals black, their bases same color as rest of body; caudal, dorsal, and anal fins tipped with grayish white; 5 black spots at base of soft dorsal fin; a black spot at base of posterior anal fin rays; a narrow grayish line along anal fin base.[21] At 40 mm color highly changeable, nearly black in aquarium, much lighter in porcelain dish; preserved specimens of this size with prominent dark spots at base of soft dorsal fin.[17] At 90 mm body yellowish tan with roundish black spots; ca. 15 spots of various sizes and shapes in central area of sides, 3 on dorsal base posteriorly, 1 on anal base, 4 on frontal area of head; lobate portion of dorsal and anal narrowly edged with black; pelvic fins black-edged along first spine; pectorals completely hyaline.[17] At 185 mm caudal still with white edge; dark spots at base of soft dorsal more conspicuous.[16] A 208 mm TL specimen was observed to change color from completely yellow, to yellow mottled with black, and to completely black.[42]

AGE AND SIZE AT MATURITY

Age at maturity, 1+; [43] minimum size at maturity, males mature by 445 mm,[43] females by 455 mm.[8]

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Lutjanus analis
Lutjanus apodus
Lutjanus campechanus
Lutjanus cyanopterus
Lutjanus griseus
Ocyurus chrysurus

snappers
Lutjanidae

FAMILY LUTJANIDAE

Lutjanids occur in the Atlantic, Indian, and Pacific oceans. Although this is primarily a tropical family, some of its members have been recorded as far north as the Gulf of Maine. Snappers are typically benthic, marine species, but occasionally enter estuarine waters. The family includes about 23 genera and 230 species.

In these fishes the snout is typically somewhat flattened above, they have no opercular spines (although the edge of the preopercle may be finely serrated), there are teeth on the vomer and palatines, usually enlarged canine teeth on the jaws, and three anal spines, the caudal fin is emarginate or forked, the two dorsal fins are continuous but may have a shallow notch between them, the scales are ctenoid, and there are usually 24 vertebrae.

Lutjanid fishes produce small pelagic eggs (in *Lutjanus griesus* ripe eggs 0.44 mm in diameter). Larvae have not been described for any of the regional species. Juvenile snappers are frequently taken in mangrove swamps which appear to function as nursery areas, and juveniles of some species are occasionally carried northward along the Atlantic coast beyond the normal adult range.

Lutjanus analis (Cuvier), Mutton snapper

ADULTS

D. X–(XI), (13)–14; A. III, (7) [3] 8–9; C. 35–36 (9–10+9+8+8–9); [18] P. 15–17; V. I, 5 (GDJ); total scales 67; pored lateral line scales 47–51; [3] scales on cheeks ca. 7; [23] scales between dorsal origin and lateral line 8; [14] total gill rakers (including rudiments) 6–8+12–13; [3] vertebrae 10+14.[18]

Depth in SL, 2.5–3.2; [7] head in TL, 2.94; [14] eye in HL, 5.67, snout 2.25.[23]

Body rather deep, compressed; back strongly elevated; profile straight and rather steep from snout to nape; snout long, pointed; [23] mouth small,[14] maxillary reaching [6] or failing to reach front of eye.[14] Upper jaw with narrow band of villiform teeth, outside of which is a single series of larger teeth; [23] canine teeth relatively small, those at front of upper jaw much smaller than more posterior larger teeth; [7] vomerine tooth patch without a distinct posterior projection on median line; [3] tongue with very small median patch of teeth.[23] Edge of preopercle rather coarsely serrated. Middle ray of anal more or less produced; [6,12] caudal fin deeply emarginate.[7]

Pigmentation: Olive green dorsally, ventral surfaces white, tinged with red; sides with both plain and barred pattern (usually barred when resting, nearly uniform when swimming). Barred pattern comprised of about 6 pale vertical bars. Scales sometimes with pale blue spots which form irregular streaks running obliquely up and back. A black spot, smaller than eye, just above lateral line and below front of dorsal (sometimes lacking in large specimens). A red phase occurs in water over 30 m deep, red dorsally, paler below; irregular blue markings below eye; iris fiery red; anal, lower part of caudal, and pelvics reddish to rosy; dorsal with yellowish edge; upper edge of caudal yellowish, posterior edge dusky or black; pectorals transparent, but tinged with red and with dark olive bar across bases.[2,3,7,12,15,21,23]

Maximum length: 770 mm.[4]

DISTRIBUTION AND ECOLOGY

Range: Gulf of Maine to Cabo Branco and San Sebastian Island, Brazil, also Gulf of Mexico and the Caribbean; [4] introduced into Bermuda.[7]

Area distribution: Atlantic coast, Chesapeake Bay area (JAM).

Habitat and movements: Adults—found offshore [2] in open waters as well as around both natural [7] and artificial reefs [13] and rocky areas; [2,13] inshore in coastal mangrove swamps,[4] protected grassy bays, and tidal creeks and bights surrounded by mangrove.[12] Recorded from a wide variety of bottom types: coral,[8,11] alcyonarian growths, sponge,[2] turtlegrass,[12,20] rocks,[8,11] sand,[7,20] and shell.[14] Depth 5 [8]–86 m.[22] Form schools during spawning period,[4,11] and in dense aggregations near shore between June and August.[20]

Larvae—no information.

Juveniles—inshore,[1,10,16] sometimes entering harbors [9] and river mouths; [5] also recorded from shallow reefs [11] and from over grassy areas.[2] Salinity range 4.5–37.3 ppt.[19] Temperature range 14.4 [1]–34 C.[19] Specimens 22–66 mm long inshore at Tampa Bay, Florida, June to December.[3] Juveniles move northward along the coast, appearing at Woods Hole, Massachusetts, from August to October.[9,10,17]

SPAWNING

Season: July and August in Florida [8,11] (although small juveniles recorded from March to August [19]).

Fecundity: 1,365,975 in a 512 mm FL female.[20]

EGGS

Described as being nonadhesive and about the size of a rice grain.[6]

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Minimum size described, ca. 50 mm.[17]

Tongue teeth lacking in young.[23]

Pigmentation: Specimens ca. 50 mm (and smaller) [17] to at least 75 mm FL with distinct banded pattern and prominent lateral spot. In a specimen of 75 mm FL there are approximately 7 somewhat oblique broad lateral bands.[1] Lateral spot extended below lateral line up to at least 187 mm.[12] A specimen ca. 200 mm long with narrow blue stripes and broader yellowish ones; cheek with

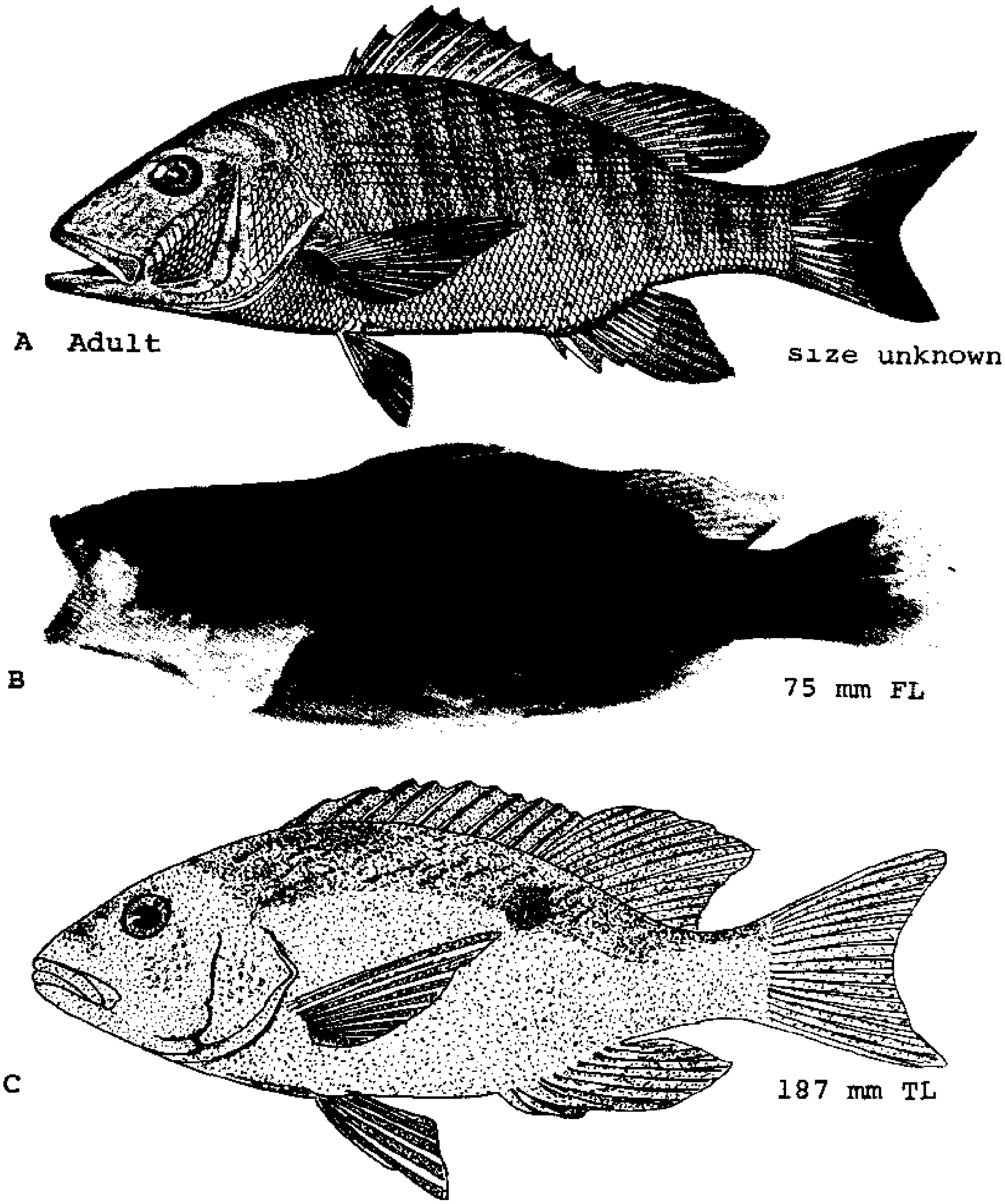

Fig. 71. *Lutjanus analis*, Mutton snapper. A. Adult, size unknown. B. Juvenile, 75 mm FL. C. Juvenile, 187 mm TL. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 517. B, Alperin, I. M., and R. H. Schaefer, 1965: 6. C, Böhlke, J. E., and C. C. G. Chaplin, 1968: 352 © Academy of Natural Sciences of Philadelphia. Used with permission of authors and publishers.*)

2 or 3 pale blue stripes; belly rosy; pelvics and anal rosy; caudal greenish with slight rosy wash and dark edges; mouth pale inside.[23] Young described as having blue spots on body.[12]

AGE AND SIZE AT MATURITY

A female reported as mature at 402 mm FL.[20]

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Lutjanus apodus (Walbaum), Schoolmaster

ADULTS

D. X, 14; A. III, 8;[3] C. 31–33 (7–8+9+8+7–8);[22] P. 16[3]–18;[7] V. I, 5 (GDJ); transverse scale rows (usually 40–43);[10] pored scales 36–45 (usually 41–45); scales between dorsal origin and lateral line in posteroventrally directed row, 5–6 (7);[3] scale rows on cheek, ca. 7;[23] total gill rakers (excluding rudiments) 5–7+7–9, gill rakers on lower limb (including rudiments) 11–15;[3] vertebrae 10+14.[22]

Depth 0.4 of length;[14] head 2.5 times in length. Proportions as times in HL: Eye 4.33, snout 2.67.[23] Proportions as percent SL for a specimen 408 mm SL: Head length 38.4; eye 6.9; snout 17.1; maxillary 16.1.[17]

Body rather deep,[14] moderately compressed; back considerably elevated;[23] maxillary extended to front of orbit.[14] Upper jaw with narrow bands of villiform teeth, outside of which is a single series of larger teeth; teeth on vomer in arrow-shaped patch with backward prolongation at midline; tongue with a single large oval patch of teeth, its length more than twice its width. Preopercle with posterior margin directed somewhat forward, and with upper edge finely serrated.[23]

Pigmentation: Yellowish brown,[2] dull brownish,[13] yellow,[7] or gray with suffusions of yellow;[8] pale below;[2] also described as dark greenish above, orange on sides and below;[14] sides with 8 to 12[12] narrow pale vertical bars[2] (sometimes lacking in adults[7] and sometimes not evident in shaded conditions); scales of lower sides each with a central orange spot, these forming streaks along scale rows;[2] head greenish above, orange on sides,[14] and sometimes with reddish tinges;[8] an ocular stripe sometimes present; a blue subocular line,[2] sometimes broken into series of dashes and spots,[8] from snout to angle of opercle;[2] no pale triangle[8] or whitish line below eye;[3] iris yellowish brown;[2] fins generally yellowish[25] to pale orange; dorsal with blue spots;[8,14] spinous dorsal distinctly edged with orange.[2,23]

Maximum length: 672 mm.[4]

DISTRIBUTION AND ECOLOGY

Range: Both sides of the Atlantic;[8] in the western Atlantic, *Gulf of Maine to San Sebastian Islands, Brazil;* also Bermuda and the Caribbean.[4]

Area distribution: Coast of New Jersey;[16,18] Cape Charles City, Virginia.[1]

Habitat and movements: Adults—a schooling species[2] found in open water near coral reefs[9] as well as in rocky areas;[2] commonly associated with elkhorn coral;[7] also in coastal mangrove swamps,[4] tidepools, tidal creeks lined with mangrove,[8] freshwater springs,[10] and around mouths of rivers.[20] Found over bottoms of coral,[7] rock,[2] sand,[9] grass and marl.[8] Minimum salinity, 0.0 ppt.[9] Maximum recorded depth, 69 m.[19] School close to rocks and coral by day; feed in rocky areas at night.[2]

Larvae—no information.

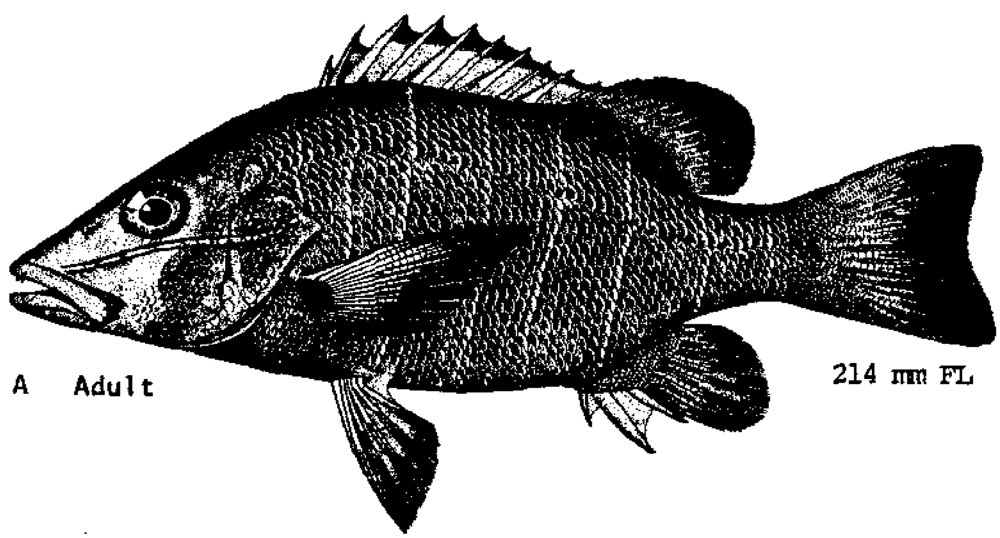

Fig. 72. *Lutjanus apodus*, Schoolmaster. A. Adult, 214 mm FL. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 515.*)

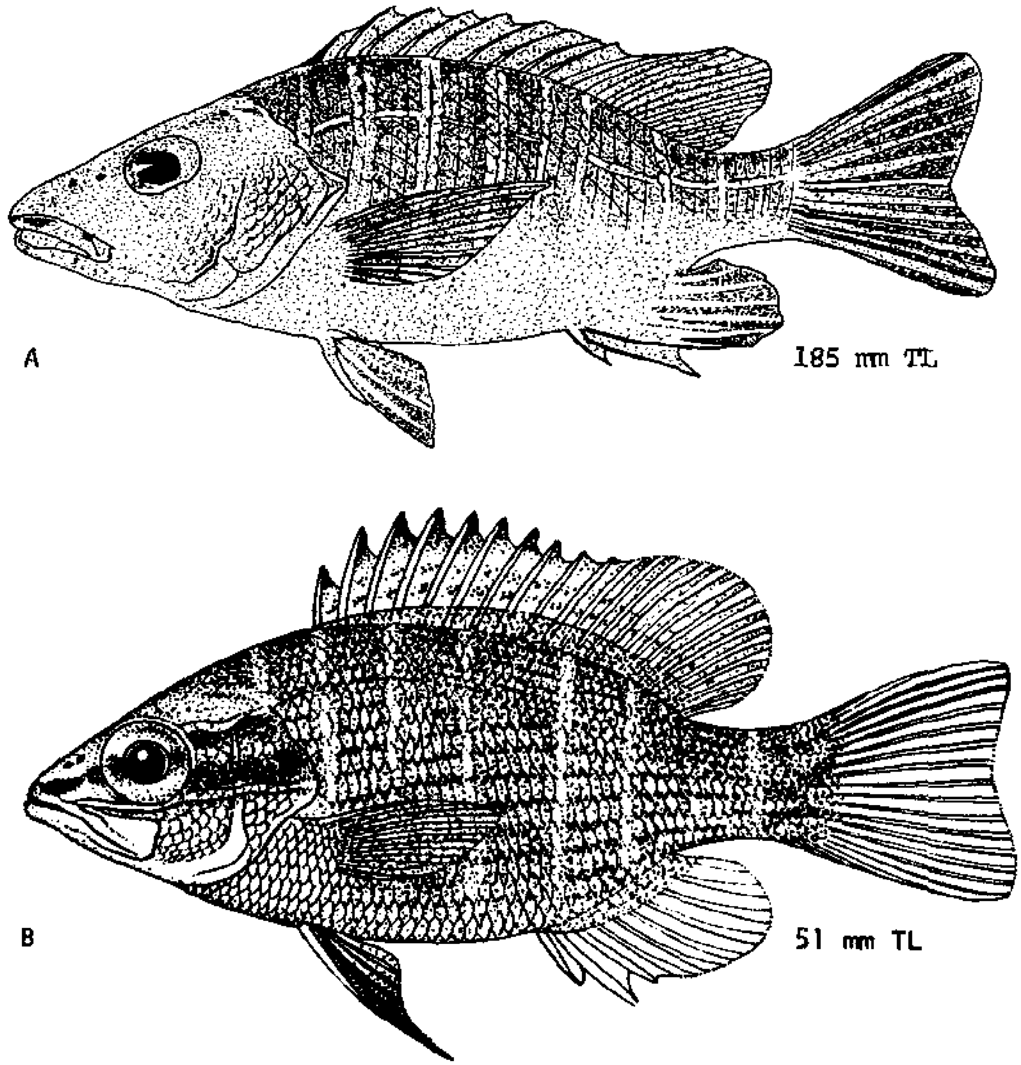

Fig. 73. *Lutjanus apodus*, Schoolmaster. A. Juvenile, 185 mm TL. B. Juvenile, 51 mm TL. (*A, Böhlke, J. E., and C. C. G. Chaplin, 1968: 356 © Academy of Natural Sciences of Philadelphia, with permission of authors and publisher, Tamiko Karr, delineator. B, Fowler, H. W., 1949: fig. 3.*)

Juveniles—around brush and other debris near or on grassflats; also along rocky shores and on both inshore and offshore reefs; [2] common in coves near shore.[11] Specimens 21–124 mm long inshore in Tampa Bay, Florida, May to February; [5] young move northward along coast, appearing at Woods Hole, Massachusetts, in August and September.[6,16]

SPAWNING

Season: In the Caribbean possibly in winter; ripe adults in April, May, and June, but peak probably earlier; [21] also small juveniles observed on November 30 and August 22 (FDM).

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Minimum size described, 30 mm.[18]

At 51 mm TL, depth 2.8, head 2.5 times in TL; snout 3.2, eye 3.75 times in HL.[18] In young second anal spine to or beyond tip of third.[9]

Pigmentation: Two color phases, banded and nonbanded occur. At 30 mm grayish yellow with series of longitudinal yellow lines formed, apparently by single yellow spot on individual scales; a brown line, slightly wider than pupil, from snout through eye to above posterior margin of opercle and two narrow pale lines on cheek; in banded phase narrow light vertical line separate a series of broader dark bands on sides; anteriormost light line from anterior base of spinous dorsal through pectoral base.[13]

Specimens ca. 37–50 mm long variously described. According to Bean, upper parts dark bluish; a blue streak as wide as pupil from snout through eye to end of head; dark spots on scales form longitudinal stripes on body; pectorals, pelvics, and caudal pale; dorsal and anal spotted; membrane of spinous dorsal edged with black (description based on Chesapeake Bay specimen).[1] According to Smith, body pale yellow with 6 or 8 dark crossbands, a dark line from snout through eye to upper end of gill opening, several narrow dark lines on head behind eye, anal fin red.[15]

At 51 mm longitudinal rows of dark spots on body; a dark olive brown bar from tip of snout to eye; a pearly blue line from preorbital region to lower edge of orbit; dorsal gray throughout, spinous dorsal with dark gray margin; caudal and anal gray; pectoral pale; pelvics whitish basally, gray and black distally. Iris gray to white.[18]

Banded specimens 125–150 mm long were noted to lighten distinctly when moving from algae to bare sand.[13] A specimen 185 mm long showed the typical adult banded pattern.[9]

Color of young in life: Greenish, with ca. 8 very narrow vertical paler bars on body; scales on lower part of body with central orange spots forming faint streaks along rows of scales; belly pearly; head greenish; a black streak through eye to nape; a narrow sharply defined blue streak below eye from snout to angle of opercle; spinous dorsal edged with orange; pelvics, anal, and caudal pale orange-yellow; pectorals paler.[23]

AGE AND SIZE AT MATURITY

No information.

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Lutjanus campechanus (Poey), Red snapper

ADULTS

D. (IX) X, (13) 14 (15); A. III (IV), (7) 8–9 (10);[1] C. 35–37 (9–10 + 9 + 8 + 8–10);[31] P. 15–18;[1] V. I, 5;[8] pored lateral line scales 46[33]–51 (usually 47–48); scales above lateral line 7–10, below 15–19;[34] scales around caudal peduncle 25–27;[2] scales above opercle in 6–7 rows;[33] scale rows on cheek 5–6;[28,33] total gill rakers (including rudiments) 6–8 + 14–16;[1,33] gill rakers on lower limb (excluding rudiments) 8–10;[28] vertebrae 10 + 14.[31]

Proportions as times in TL: Depth 2.57–2.82, head 2.6–2.8.[3,32]

Body compressed,[8] rather deep;[4] upper profile rounded; mouth medium;[3] jaws equal;[8] gape extended nearly to or slightly beyond anterior margin of eye.[3,28] Vomerine tooth patch anchor-shaped and with median posterior extension;[1] teeth present on tongue;[32,33] upper jaw with row of small canines in front, and a narrow row of teeth behind canines; lower jaw with row of small, subequal canines in front, and narrow band of smaller teeth behind.[3] Preopercle finely serrate above.[32] Pectoral fin reaching to or beyond vertical from anal origin except in very large specimens;[28] anal fin pointed;[22] caudal fin slightly forked.[4]

Pigmentation: Body and head scarlet[8] or rose-red,[32] sometimes with silvery overtones;[22] belly and throat paler than rest of body; scales above lateral line with greenish centers or bluish streaks (although these disappear with age);[3,32] in small adults (up to ca. 305–457 mm) a conspicuous black spot above lateral line under anterior rays of soft dorsal;[4,22] inside of mouth white;[32] iris scarlet red.[3,22] All fins red;[22] dorsal orange toward outer margin[28] with blackish edge;[32] caudal fin edged with fine black streak; base of pectoral fin with diffuse black spots.[3]

Maximum length: 914 mm.[32]

DISTRIBUTION AND ECOLOGY

Range: New Jersey[10] to Florida and through Gulf of Mexico to Campeche Bank; absent in the Bahamas and the Caribbean.[33]

Area distribution: New Jersey.[10]

Habitat and movements: Adults—a benthic species (although sometimes found near surface)[34] usually found in deep channels,[20] on banks,[2,7,16,18] ridges,[34] cliffs,[24] or around rock piles,[34] wrecks, or other submerged debris[15,24] over bottoms of hard limestone,[12] coral, shell, sponge, gravel, rock,[21] sand, and mud; also sometimes associated with submerged vegetation.[24,34] Recorded from coral patches as far north as North Carolina.[29] Usually found more than 24 km offshore, but sometimes as close as 4 km.[9] Maximum distance from shore ca. 1130–1290 km.[11] Maximum recorded depth 183–219 m,[12] but possibly as deep as 1372 m;[21] specimens collected at 9–55 mm, average depth 53 m.[30] Recorded salinity range 33–37 ppt.[12] Recorded temperature range 12.8–27.8 C[30]

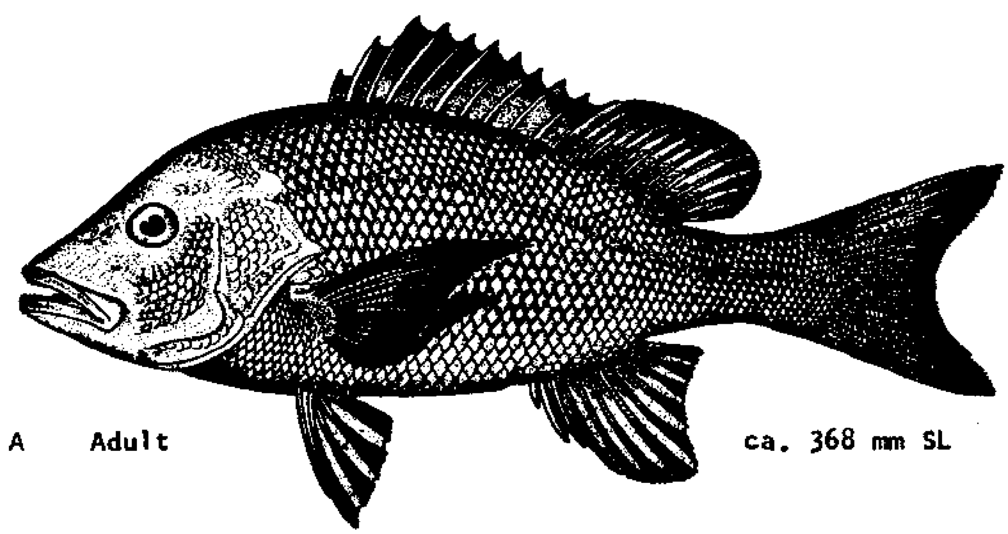

Fig. 74. *Lutjanus campechanus*, Red snapper. A. Adult, ca. 368 mm SL. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 516.*)

(although also recorded in water having a maximum surface temperature of 30.6 C [21]).

Generally move inshore in summer, offshore in winter.[12,24] Some tagged individuals have shown no significant movement,[14] others have moved considerable distances; one individual moved about 148 km in about 6 years,[18] others moved 46–278 km in 357–1163 days.[22]

Larvae—no information.

Juveniles—inshore, along beaches [2,4] and in channels; [26] sometimes associated with coral and grass,[24] although sometimes found miles from reefs; [19] typically over bottoms of sand, mud,[12] shell,[17] or gravel.[34] Maximum recorded distance from shore, a 19 mm specimen at 3 km.[17] Depth range 9–91 m.[24,25] Recorded salinity range (possibly including adults), 24.6–39.8 ppt. Recorded temperature range (possibly including adults), 15.4 [25]–30 C.[2] Young and juveniles stray northward in September and October.[5,23]

SPAWNING

Location: Spawning areas described as in 16 [24]–37 [12] m over bottoms of hard sand and shell with rocky reef areas,[24] although ripe fish have also been observed ca. 1130–1290 km offshore; [11] actually spawning may take place at surface.[34]

Season: In Gulf of Mexico (generally) June to mid-September; [26] in Texas early June or July to mid-September with peak in July and August [12] (although females with developing eggs have been observed as early as May 3 [2]); in Florida early July to mid-September, peak probably July and August; [34] in southern hemisphere, January.[11]

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Juveniles characteristically with a black lateral spot above lateral line just under anterior rays of soft dorsal.[3,4,18,32] Specimens up to ca. 50 mm long generally red, body marked with ca. 7 double dark crossbars; lateral blotch extended below lateral line; spinous dorsal dusky; soft dorsal with dusky median zone and dark edge; caudal pale with narrow dark border.[6] A specimen ca. 114 mm long with 5 dark vertical bands on body, the first (nearly as wide as eye) in front of spinous dorsal, the remainder under dorsal fin; lateral blotch contained in fourth lateral band and extending slightly below lateral line; dorsal and caudal narrowly edged with black; spines and distal parts of pelvics milk white; anal rosy.[8]

AGE AND SIZE AT MATURITY

Females 3.8 years, males 4.0 years.[11] Minimum length reported, 300–320 mm for both sexes; [34] otherwise, males 471 mm, females 460 mm.[11]

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Lutjanus cyanopterus (Cuvier), Cubera snapper

ADULTS

D. X, 13 [7]–14; A. III, 7–8; [2] C. 9+8 (GDJ); P. 15 [13]–18; [12] V. I, 5; pored lateral line scales 45–50; [2,13] scales around caudal peduncle 25–26; [15] scales on cheek 7 [18]–10, usually 9; [2] scales posterior to eye 4–5; scales above lateral line 7, below 12–14; [13] total gill rakers (excluding rudiments) 5–7+7–8; gill rakers on lower limb (including rudiments) ca. 11–15.[2]

Proportions as times in SL: Depth 2.2 [7]–3.4,[4] head 2.6 [14]–2.7.[7] As times in HL: orbit 8.9.[14] As percent SL: head 33.95–37.75, depth 35.30–40.11. As percent TL: head 28.78–31.68, depth 28.78–29.45.[13]

Body elongate, rather robust; back little elevated; profile from snout to nape nearly straight; snout long, thick, rather acute; [11] mouth variously described as extending to anterior [7] or posterior margin of orbit [15] or to middle of eye.[11] Vomerine tooth patch without a distinct posterior extension on median line; upper and lower jaws with very strong, subequal canines.[2] Edge of opercle finely serrate.[11] Pectoral fin not extended to vertical from anal fin; anal fin rounded.[15]

Pigmentation: Generally grayish,[5] dusky gray,[9,11] greenish,[15] reddish,[10] or maroon-bronze,[13] sometimes tinged with red, especially anteriorly; [5,15] head with trace of blue subocular line; in life body with several pale bars on dark background; [1] ventral surfaces paler than rest of body; [11,15] dorsal, anal, and caudal typically grayish [5] or grayish black; [11] anal sometimes reddish; pectoral almost colorless,[5] olivaceous, base and inner margin dusky; [11] pelvics somewhat reddish,[5] blackish at tips; [11] eye dark red.[15]

Maximum length: 1418 mm TL.[14]

DISTRIBUTION AND ECOLOGY

Range: Chesapeake Bay, Virginia,[8] to Cabo Branco, Brazil, and throughout the Caribbean.[5,6,7]

Area distribution: Lower Chesapeake Bay, Virginia.[8]

Habitat and movements: Adults—a shore species [6] found on sub-marine ledges; [5] in channels; around patch reefs and offshore reefs; [1] and in shallow inlets, tidal creeks,[13] and mangrove swamps.[3,5] Typically over bottoms of coral, brown sponge,[13] limestone,[5] sand,[13] marl,[5] or grass.[1] Maximum depth 55 meters.[13] Enter lower Chesapeake Bay as stray in fall.[8]

Larvae—no information.

Juveniles—recorded from estuarine areas [15] in rivers,[7,9] streams, and canals; [10] also found on shallow turtlegrass beds (FDM). Salinity range, 3.7 [9]–37 ppt (FDM). Temperature range, 24.5–31.0 C.[9]

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Upper jaw reaching to vertical from center of eye in "young." [15]

Preserved specimens 130–445 mm long (thus including both juveniles and adults), dark grayish brown above, pale below with brown punctulations; centers of scales on lower parts of sides pale, making pale streaks along rows of scales; no markings on head; dorsal, caudal, anal, and distal third of pelvics very black.[12] "Young" described as having faintly barred pattern on sides.[5]

AGE AND SIZE AT MATURITY

No information.

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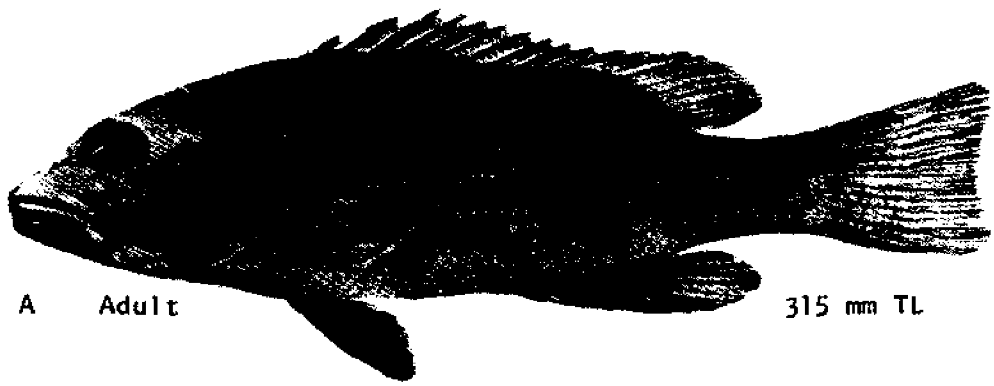

Fig. 75. *Lutjanus cyanopterus*, Cubera snapper. A. Adult, 315 mm TL. *(A, Böhlke, J. E., and C. C. G. Chaplin, 1968: 354 © Academy of Natural Sciences of Philadelphia, used with permission of author and publishers.)*

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Lutjanus griseus (Linnaeus), Gray snapper

ADULTS

D. X, 14; A. III, 7–8;[6] C. 32–33 (8+9+8+6–8);[48] P. 15–17;[6] V. I, 5;[36] transverse scale rows 48–51,[1] pored lateral line scales, 44–47,[6] scale rows on cheek, 7[52]–10;[6] oblique scale rows between dorsal fin and lateral line, 7;[33] scales around caudal peduncle, 21–23;[52] total gill rakers (excluding rudiments) 6–8+8–9; gill rakers on lower limb (including rudiments) ca. 12–14;[6] vertebrae 10+14.[48]

Proportions as times in TL: Head 2.6[1]–2.75,[51] depth 2.35[1]–3.25.[51] Proportions as times in SL: depth 2.6–3.2, pectoral fin 3.7–4.2.[6] Eye 4.66 times in HL.[51]

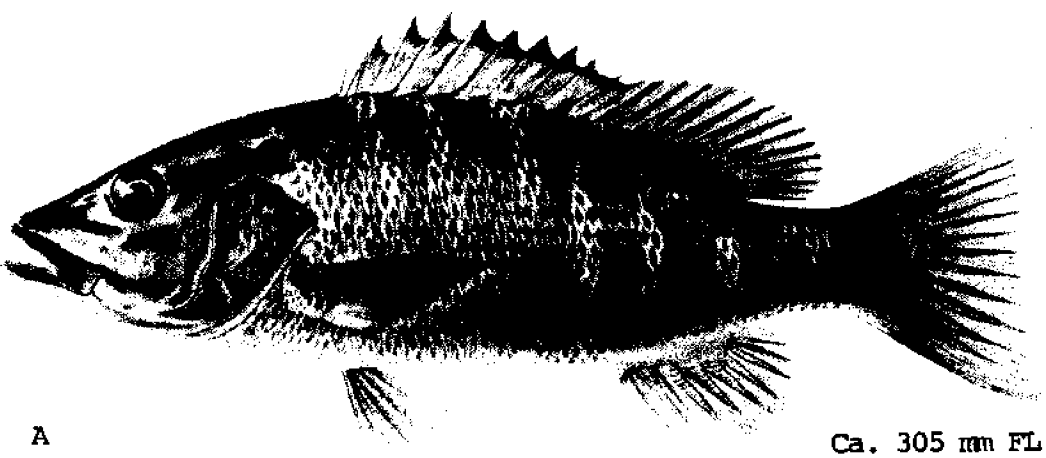
Body elongate; back moderately elevated, not strongly compressed, profile straight or slightly concave over snout; head moderate; snout rather pointed; mouth large, terminal; maxillary reaching to or a little beyond anterior margin of pupil. Preopercular margin finely serrate.[1,3,51] Gill rakers short, thick.[4] Teeth present on jaws, vomer, palatines, and tongue; upper jaw with 1 or 2 pairs of canines; lower jaw with outer series enlarged; villiform teeth on vomer in anchor-shaped patch with triangular anterior head and definite median backward projection;[1,6,12,19] tongue with single oval patch of teeth.[51] Scales present on soft parts of vertical fins;[1] top of head, snout, and jaws naked.[3] Caudal fin concave, the upper lobe longest.[1]

Pigmentation: Dorsal surfaces dark green, gray-green,[1] gray (sometimes with white counter shadings),[4] olive,[19] mahogany,[20] or reddish brown;[4] upper scales sometimes with pearly white edges, brassy black centers.[3] Scales on sides sometimes with orange or rusty centers which form definite rows of spots.[1] No black lateral spot.[11,12] Ventral surfaces coppery red, bright red, or with light red markings;[1] lower jaw grayish.[3] Spinous dorsal fin dusky or blackish, its margin darker and tinged with maroon or entirely edged with red; soft dorsal dusky, its anterior margin narrowly edged with white; anal fin reddish with white margin; caudal fin grayish, olivaceous, or reddish black; pelvic fins whitish with faint red markings, or reddish throughout; pectorals pale, flesh-colored.[1,3,19,51] Eye red.[52] Instant color changes occur[20] and color is apparently correlated with environment. In inlets usually gray with some orange tinge;[49] in mangrove swamps generally dark; in high marl tributaries, gray-green with brick red scale centers and head markings; in brackish coffee-colored water rich red-bronze to umber;[27] also, in "heavily stained" water often maroon with considerable black and some red in dorsal fin;[48] in channels and over reefs, generally pale; in deeper water, generally reddish;[4] at evening over clear sand, very pale;[50] at night assumes pattern of bars and blotches.[4]

Maximum size: Length possibly to 982 mm and weight to 13.8 kg, but identity of this specimen is questioned;[3] rarely exceeds 3.6 kg, maximum probably 8.2 kg.[4]

DISTRIBUTION AND ECOLOGY

Range: Inshore marine, brackish, and sometimes freshwaters from Cape Cod, Massachusetts, to Rio de Janeiro, Brazil; also Bermuda and tropical and subtropical coastal waters of eastern Atlantic.[3,23,30]



A

Ca. 305 mm FL

Fig. 76. *Lutjanus griseus*, Gray snapper. A. Adult, ca. 305 mm FL. (*A, Evermann, B. W., and M. C. Marsh, 1902: pl. 17.*)

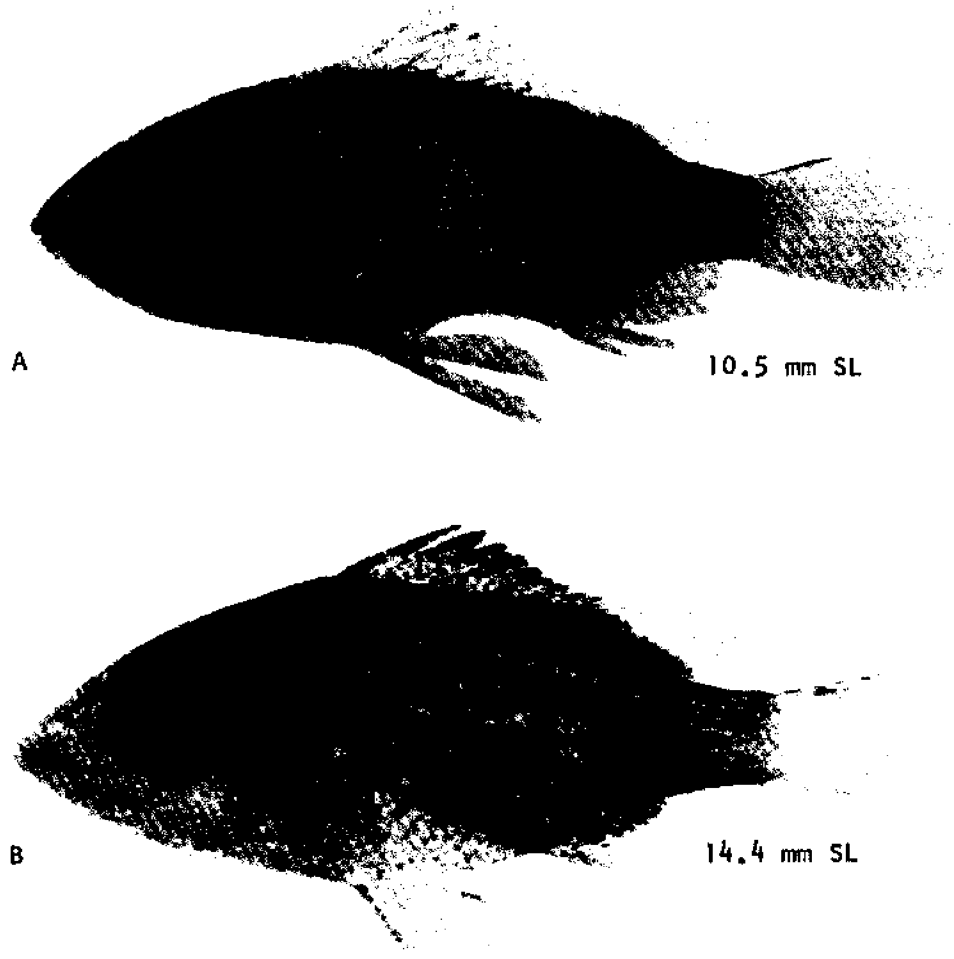


Fig. 77. *Lutjanus griseus*, Gray snapper. A. Juvenile, 10.5 mm SL. B. Juvenile, 14.4 mm SL. (*A, B, Starck, W. A., II, 1964: fig. 18.*)

Area distribution: New Jersey,[5,38] Delaware,[31] lower Chesapeake Bay and lower Rappahannock and York rivers, Virginia.[1,40]

Habitat and movements: Adults (although general data may include some juveniles)—a schooling species [3] (with schools often floating at mid-depths by day and always dispersing at dusk). *Found in a wide variety of habitats;* in marine waters in deeper channels and around offshore reefs;[1] in estuaries and coastal mangrove swamps, sometimes among roots in very shallow water in areas washed by swift tidal flow;[2,8,19] also, but less frequently, along edges bordered by grass;[4] found around rocks, coral heads, gorgonian patches, ledges, wrecks, pilings, jetties, wharves, and bridges; also in bayous [3] and lagoons,[46] sometimes preferring deep holes in lagoons;[38] ascend freshwater streams, creeks [1,22,34] and rivers [2] and recorded from freshwater springs and lakes.[3,4,32] Considering the overall habitat, found over a variety of bottom types: mud [3] (sometimes apparently preferred [21]), marl, sand,[24] gravel,[26] coral,[4] shell,[29] and rocks,[12] or rock covered with sand;[4] sometimes over inshore grassbeds, and sometimes associated with sponge, alcyonarian, or algae growths.[3,4,15] Frequently hide in shells and crevices.[45] Minimum depth, a "few inches" [18] (although life history stage uncertain, JDH). Maximum recorded depth 77 m,[47] but also recorded in water up to 124 m deep [4] (depth of capture unknown). Salinity 0.0–47.7 ppt.[3] Lower lethal temperature, between 11 and 14 C. Maximum recorded temperature 27.8 C.[47] Maximum distance out, 32 km.[3]

Annual inshore-offshore movements occur: Brice [14] and Pew [28] felt that the species moved offshore to deeper water in winter, while Starck found adults offshore in summer and inshore in fall, winter, and spring. During cold periods form dense schools in deeper water. Migrate to reefs to spawn,[4] although all movements appear to be relatively limited; thus 21 to 56 km in 35–41 days,[41] 75 km in 7 days,[4] and 122 km in 106 days.[49] Diurnal movements occur, move to inshore grass beds at night to feed, out by day.[4]

Larvae—specimens 10 mm long in grassbeds.[4] Recorded temperature range 15.6–27.2 C.[5] Euryhaline, although salinity limits unrecorded.[4]

Juveniles—shallow grassy areas or in close proximity to mangrove growths;[3,11,43] also bays, coastal marshes,[4] ponds,[16] bayous,[17,45] creeks, and freshwater rivers; prefer ledges formed by current and having overhanging root mats (*Thalassia*) several feet wide.[1,4] Sometimes far upriver, in spillpool below dam 96 km upstream from mouth of Delaware River in Appoquinimink Creek.[44] Found over hard, muddy, and grassy bottoms.[3] Distribution by size: specimens 12.4 to 21.8 mm SL over sand carpeted with dead blades of *Thalassia;* at lengths of up to 70 mm SL common in shallow water grass beds;[4] specimens ca. 75 mm TL reported in rivers;[37] at 70 to 90 mm SL around brush, debris, and channel edges; over 170 mm in channels, also around reefs and wrecks. Juveniles remain in inshore nursery areas to length of ca. 80 mm and in shallow water, generally, to 200 mm SL[4] or for as long as three years.[3] Small juveniles in grass beds do not school; large juveniles have weak schooling tendency. Salinity range 0.0[7,8]–36.6 ppt.[25,49] Recorded temperature range 17.2–36.0 + C.[42,43,45,49] Maximum depth 6 m.[4] Distance out 14 km.[3]

Seasonal movements occur: Specimens 27–116 mm inshore in Tampa Bay, Florida, June to February;[10] juveniles inshore at Cedar Key, Florida, August through November.[13] At 170–210 mm move from shallow water (1.8–2.4 m) to water 3–6 m deep in channels and bays.[4] Juveniles sometimes stray as far north as Woods Hole, Massachusetts, arriving there in fall.[16,24]

SPAWNING

Location: Outer reefs[4] or, possibly, shoal areas in Florida;[3] probably offshore in Gulf of Mexico,[3,17] offshore on Georgia coast.[53]

Season: In Florida specimens approaching maturity in January;[3] fish with ripening ovaries in April, June, July,

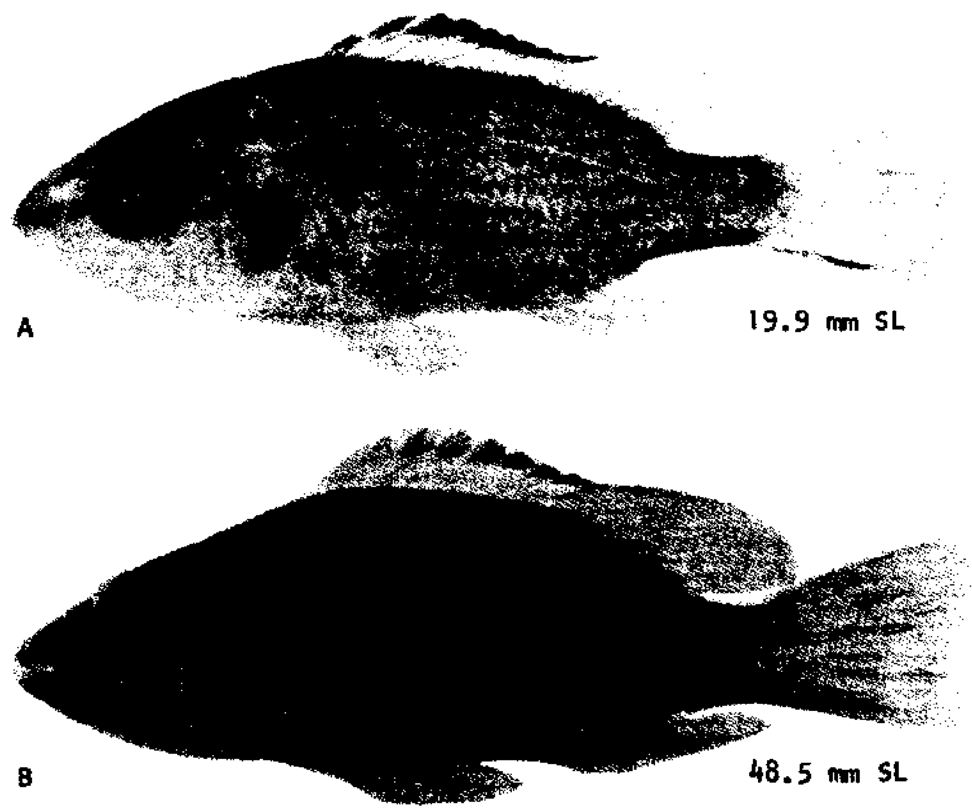


Fig. 78. *Lutjanus griseus*, Gray snapper. A. Juvenile, 19.9 mm SL. B. Juvenile, 48.5 mm SL. (*A, B, Starck, W. A., II, 1964: fig. 18.*)

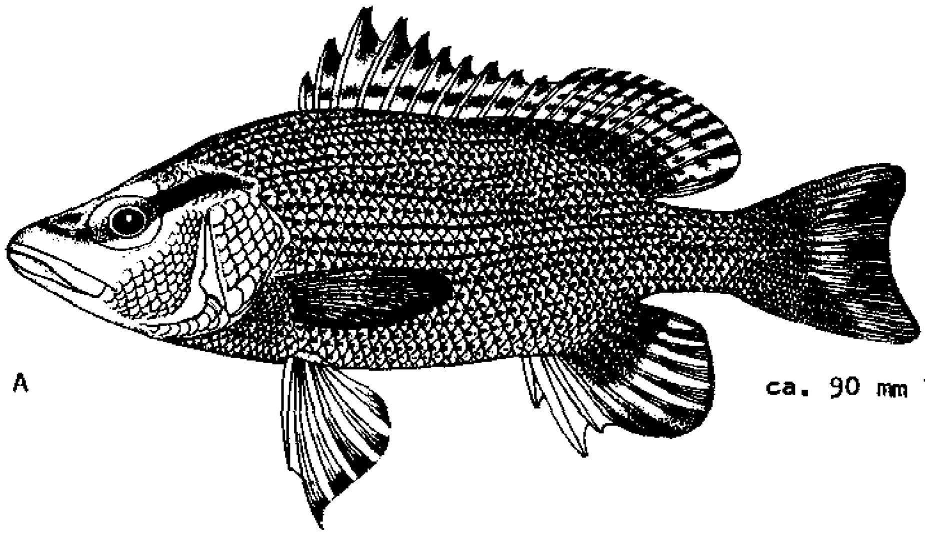


Fig. 79. *Lutjanus griseus*, Gray snapper. A. Juvenile, ca. 90 mm TL. (*A, Fowler, H. W., 1945: fig. 265.*)

and August. Spawning probably occurs more than once per season in a single individual.[4]

Time: Possibly at dusk.[1]

Duration: Possibly over a short period, and possibly during or near full moon.[4]

Fecundity: 273,000 to 274,000 per ovary; ca. 500,000 in a 315 mm female.[4]

EGGS

Location: Demersal.[4]

Ovarian eggs (apparently ripe): Average diameter 0.44 mm.[4]

Fertilized eggs: Nonadhesive.[14]

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Minimum size described, ca. 10 mm SL.

Body depth greater in young than in adults.[4] Second anal spine not reaching tip of 3rd in young.[23] Pectoral fin *relatively shorter in smaller individuals*, increasing rather rapidly in size up to 50 mm SL. At 10 mm SL, pelvic spine longer than fin; at 15–20 mm pelvic spine noticeably decreased in size relative to fin. Scales apparently formed at 14.4 mm SL.[4]

Pigmentation: At 10 mm SL little pigmentation. Specimens 12.4–21.8 mm SL dark brown and similar to dead *grass in which they were found.*[4] *At 44–53 mm usually* with a horizontal blue line along and touching lower edge of eye. This line may be broken into widely spaced spots with increased size.[39]

At sizes up to ca. 48 mm, pale with 6–8 narrow longitudinal stripes; spinous dorsal dark with a sharply defined blackish bar involving distal part of fin; extreme edge of *dorsal fin white.*[35]

Young with broad, dark, oblique stripe sometimes present from tip of snout through eye and toward anterior dorsal spine.[19]

AGE AND SIZE AT MATURITY

Mature at about 3 years.[3] Smallest mature female 195 mm SL; smallest mature male 185 mm. Some individuals of unspecified sex may have been mature at 175 mm.[4]

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Ocyurus chrysurus (Bloch), Yellowtail snapper

ADULTS

D. X, 12–14; A. III, 8–9; [2] C. 34–35 (9+9+8+8–9); [25] P. 15–16; [2] pored lateral line scales 46–51; scale rows on cheek 5–6; [24] gill rakers (including rudiments) 8–10+21–23; [2] vertebrae 10+14.[25]

Depth 2.9–3.3 times in SL.[5] Snout 3.0, eye 5.0 times in HL.[2]

Body elliptical, back a little elevated; caudal peduncle long, slender; interorbital space very convex and with sharp median keel; mouth small, oblique; maxillary reaching to very slightly beyond front of orbit. Preopercle weakly serrate; posterior margin of preopercle almost vertical. Upper jaw with narrow band of villiform teeth, outside of which is a single series of large teeth, the first 5 or 6 of these canine-like; tongue with two patches of teeth; teeth on vomer in an anchor-shaped patch with narrow posterior extension on median line; [2] teeth present on ectopterygoid (GDJ). Scales above lateral line in very oblique series, those below lateral line nearly horizontal; top of head, snout, and jaws naked; base of dorsal and anal fins scaly.[24]

Pigmentation: A prominent mid-lateral yellow or bronzy green stripe which borders posteriorly and becomes continuous with pigment of caudal fin (fading in preservative); [2] area immediately above and below lateral stripe with reddish cast; ground color above olive, violet, blue or blue-gray; area above lateral stripe with yellow spots, below with alternating reddish and pale yellow stripes on ground color which may be white or same shade as back. A blotched pattern is sometimes displayed. Iris reported as red (Bahamas and adjacent waters) and silvery (Haiti). Dorsal fin lemon yellow; anal fin light yellow; caudal fin same color as lateral stripe; pectoral fin colorless, pale salmon, or green above and yellow below; pelvics yellow, sometimes yellowish green on forward rays.[5,9,13,14,15,24] Specimens caught at night are distinctly pink above and below the mid-lateral stripe (FDM).

Maximum length: 760 mm.[3]

DISTRIBUTION AND ECOLOGY

Range: Both sides of the Atlantic; in the western Atlantic, Gulf of Maine to southern Brazil including Bermuda and the West Indies; in the eastern Atlantic recorded from Cape Verde Islands.[3,5]

Area distribution: New Jersey.[16,18,19]

Habitat and movements: Adults—a schooling species found near rocky cliffs [12] and edges of reefs [8] as well as in shoal areas; [6] associated with growths of coral,[10] gorgonians, *Orbicella*,[14] and grass over bottoms of rock, gravel, shell, sand, coral and mud; [1,5,10,12] frequently in open water between surface and top of reef [9] (thus reported as usually 1.2 to 1.8 m from bottom in water 3.6 to 4.7 m deep); [14] maximum reported depth, 188 m; [10] in water 3.6 m deep or deeper in Florida in winter.[6,8]

Larvae—no information except for comment by Christensen that the Intercoastal Waterway may serve as a nursery area for the species.[23]

Juveniles—young along shore among turtle grass and (presumably) other grasses, particularly where finger coral (*Porites porites*) is found; [1,5,14,15] specimens 55 to 72 mm long in muddy shallows of bays.[11] Recorded salinity range 29.9–36.8 ppt. Recorded temperature range 20.5–31.0 C.[23] Specimens 37–62 mm long inshore in Tampa Bay area in September and October.[4] Juveniles may move as far north as Woods Hole, Massachusetts, arriving in October.[7,17]

SPAWNING

Location: Sexually active adults on oceanic banks of Jamaica.[22]

Season: In Jamaica, sexually active fish in February, April, May, August, September, and November, suggesting year round spawning; [22] in Cuba, March through September; [3] in Florida, July.[6]

Fecundity: 99,666–1,472,594.[26]

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Minimum size described, ca. 115 mm.[20]

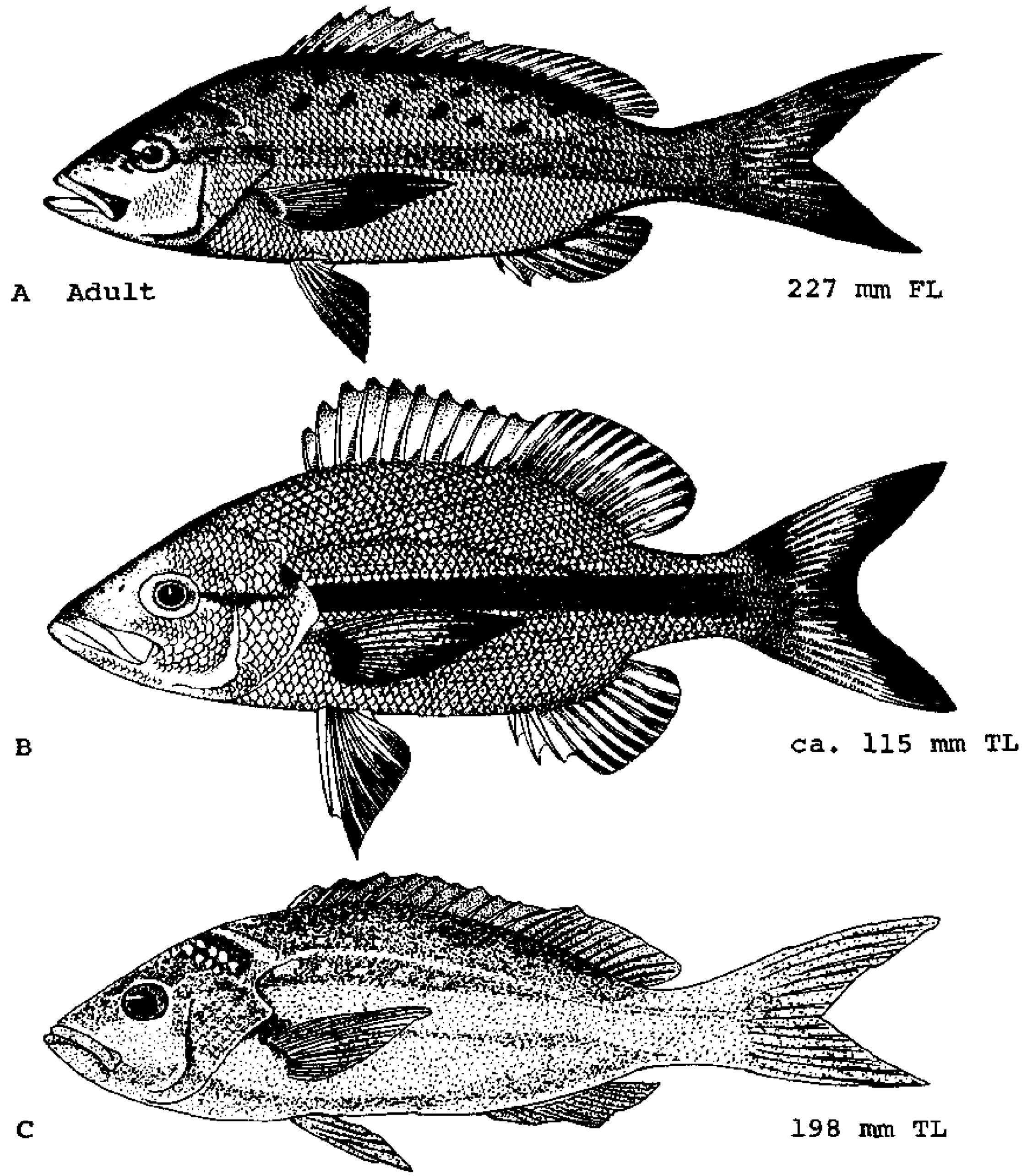

Fig. 80. *Ocyurus chrysurus*, Yellowtail snapper. A. Adult, 227 mm FL. B. Juvenile, ca. 115 mm TL. C. Juvenile, 198 mm TL. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 520. B, Fowler, H. W., 1945: fig. 266. C, Böhlke, J. E., and C. C. G. Chaplin, 1968: 358.*)

Pterygoid teeth lacking in "young."[24]

Pigmentation: "Young" sometimes with distinctly blotched pattern.[14] Large juveniles with pink background color at night (FDM).

At ca. 115 mm (thus possibly mature) lateral stripe well-developed, but apparently not forward of edge of opercle.[20]

AGE AND SIZE AT MATURITY

Minimum size at maturity, 110–119 mm.[3]

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Cookeolus boops
Priacanthus arenatus
Priacanthus cruentatus
Pristigenys alta

bigeyes
Priacanthidae

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FAMILY PRIACANTHIDAE

The priacanthids, of which there are three genera and about 18 species, occur in tropical and temperate waters of the Atlantic, Indian, and Pacific oceans. They are strictly marine species and typically occur in rather deep water.

In these fishes, which are usually bright red, the eyes are very large, the mouth is oblique, the lower jaw is projected, the body is notably compressed, there are three anal spines and a membrane between the inner rays of the pelvic fin and the body.

Larvae of the regional species, *Pristigenys alta*, have well-developed serrated spines on the head and preopercle. In early larvae (2.2 to 3.2 mm SL) the anus is positioned at a point less than one-half the distance to the end of the tail, while in advanced larvae (6.6 mm SL) it is slightly more than halfway to the end of the tail.

Cookeolus boops (Bloch and Schneider), Bulleye

ADULTS

D. X, 12–13;[1,5] A. III, 12–14; P. 18[7]–19;[5] V. I, 5;[3] C. 5+8+8+4;[2] pored lateral line scales 52–58 (61), midlateral scale rows 58–65 (69);[5] vertebrae 10+13;[2] gill rakers 5–7+17–20, total 22–26;[5] pyloric caeca 7.[3]

Proportions as percent SL: Head 32.1; depth 45.0; eye diameter 12.6; pectoral fin length 18.4;[3] pelvic spine length 19.6[5] to greater than 28.0;[1] second pelvic ray length 25.8[5] to greater than 45.0;[1] dorsal fin length 59.5; predorsal length 29.7; preanal length 62.0; least depth caudal peduncle 11.0.[3]

Dorsal profile nearly evenly convex from upper lip to base of last dorsal ray; ventral profile strongly convex from tip of mandible to insertion of pelvic fins, then nearly straight to base of first anal ray. Mouth very oblique; lower jaw strongly projecting, with broad blunt knob; maxillary reaching first third of pupil; eye large, round; snout slightly shorter than postorbital; interorbital strongly convex; preopercle serrate above and below, angled with strong conical spine reaching beyond lower posterior edge of opercle; posterior nostril nearly transverse. Teeth in narrow bands on jaws, vomer and palatines; not noticeably enlarged. Body densely scaled everywhere except lips and fins. Lateral line not conspicuously arched anteriorly, but rising gently from upper angle of opercle in low arch and gradually descending to mid-flank under last dorsal ray. First soft rays very high, reaching base of caudal when depressed; anal fin similar to dorsal; pelvic fins long, reaching base of third anal ray; pelvic spine strong, reaching just beyond anus; caudal fin truncate or very slightly rounded.[3]

Pigmentation: A freshly frozen specimen described as almost uniformly red, except top of head more rosy, dorsum of body more copper-colored; inside of mouth red, iris mostly red-orange, dusky on dorsal and posterior edge; fins red, tips of pelvics and edge of caudal dusky. Specimens also described as with dorsal and pelvics almost black, pectorals yellowish.[5]

Coloration in preservative, dark gray above, sides silvery, lighter below; tip of lower jaw, snout, and predorsal region much darker; pelvic membranes black, rays silvery; pectoral fin plain; membrane of spinous dorsal black; membrane between first 4 or 5 dorsal and anal soft rays dark, rest of fins lighter; tip of caudal dark; margin of scales between vent and anal spines blackish.[3]

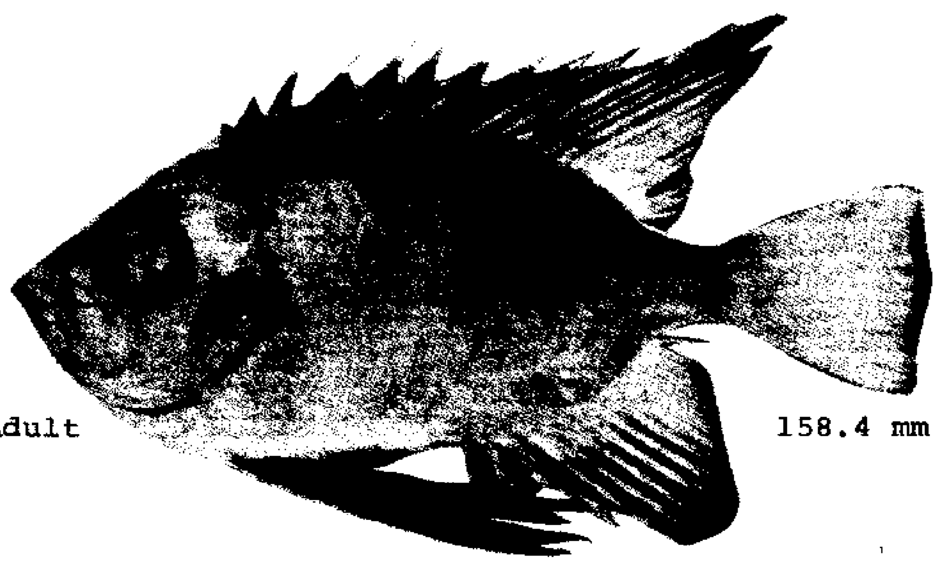
Maximum length: 507 mm SL.[5]

DISTRIBUTION AND ECOLOGY

Range: Both sides of the Atlantic and possibly throughout much of the Pacific[1] including the eastern Pacific (RAF); in the western Atlantic from off Cape May, New Jersey, to Buenos Aires, Argentina; also Barbados.[1]

Area distribution: Coast of New Jersey;[1,4,7] off Virginia capes.[1,8]

A Adult



158.4 mm SL

Fig. 81. *Cookeolus boops*, Bulleye. A. Adult, 158.4 mm SL. *(A, Caldwell, D. K., 1962: fig. 4.)*

Habitat and movements: Adults—most known specimens presumed to have been captured on or near bottom at depth range of ca. 60 to 366/411 m.[6]

Larvae—no information.

Juveniles—very young (based on a specimen 37 mm long) pelagic, live in upper layers of water and transported by currents.[1]

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

LARVAE

No information.

JUVENILES

Minimum size described, 37.0 mm TL.

Pelvics with noticeably elongate rays.[1]

AGE AND SIZE AT MATURITY

No information.

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Priacanthus arenatus Cuvier, Bigeye

ADULTS

D. X, 13–15 (usually 14); A. III, 14–16 (usually 15);[1,2] P. 17; V. I, 5;[16] C. 5–6+8+8+5–6;[5] lateral line scales 61[2]–73;[4] mid-lateral scale rows 71–85;[2] vertebrae 10+13;[5] gill rakers 6–8+21–26, totals 27–33.[2]

Head 3.2 in TL;[1] depth 2.5–3.0 in SL;[4] snout 3.85, eye 2.1, interorbital 5.1, maxillary 1.85, pectoral fin 1.7 in head.[1]

Body elongate, rather strongly compressed,[1] oblong,[13] ventral outline anteriorly much more strongly convex than dorsal outline; head deep; snout short; mouth moderate, nearly vertical; lower jaw projecting. Teeth small, pointed, in narrow bands on jaws, vomer, and palatines. Preopercular margin finely serrate, with angle produced into a short, flat, serrated spine; opercle with an indentation slightly above and behind preopercular spine. Scales small, ctenoid. Dorsal fin continuous, spines slender and pungent, soft rays not much higher than spines; caudal fin margin slightly concave; pelvic fins very long, their inner margins attached to abdomen by membrane; pectoral fins short.[1]

Maximum length: Ca. 407 mm.[4]

DISTRIBUTION AND ECOLOGY

Range: Both sides of the Atlantic; in the western Atlantic from Massachusetts to Argentina (35° S), also Bermuda and Cuba.[2,6,7,10]

Area distribution: Buckroe Beach, Virginia.[1]

Habitat and movements: Adults—a schooling, shore species often encountered over reefs; seldom in water less than ca. 15 m deep,[4,7] but occasionally in harbors;[6] over bottoms of mud, sand, coral, and shell.[8] Minimum depth 1.5 m.[6] Maximum depth 91 m,[8] or possibly 444 m.[13] Maximum distance out, 19.3 km off Fire Island, Long Island.[15]

Larvae—no information.

Juveniles—individuals 30.5–40.6 mm long reported in an aggregation of ca. 5000 in water ca. 9 m deep (this may have been a response to underwater lights).[17]

Small specimens apparently move northward;[14] thus present from New Jersey northward (at least to Woods Hole, Massachusetts) from September to November.[3,11,12,14]

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Minimum length reported, 20.5–40.6 mm, but these specimens undescribed.[17]

Preopercular spine smaller than adult.[10]

Depth 2.8 mm SL; eye 2.5 in HL.[10]

Pigmentation: In small specimens dorsal unspotted, darkly shaded; eight small black spots along lateral line.[10]

AGE AND SIZE AT MATURITY

No information.

LITERATURE CITED

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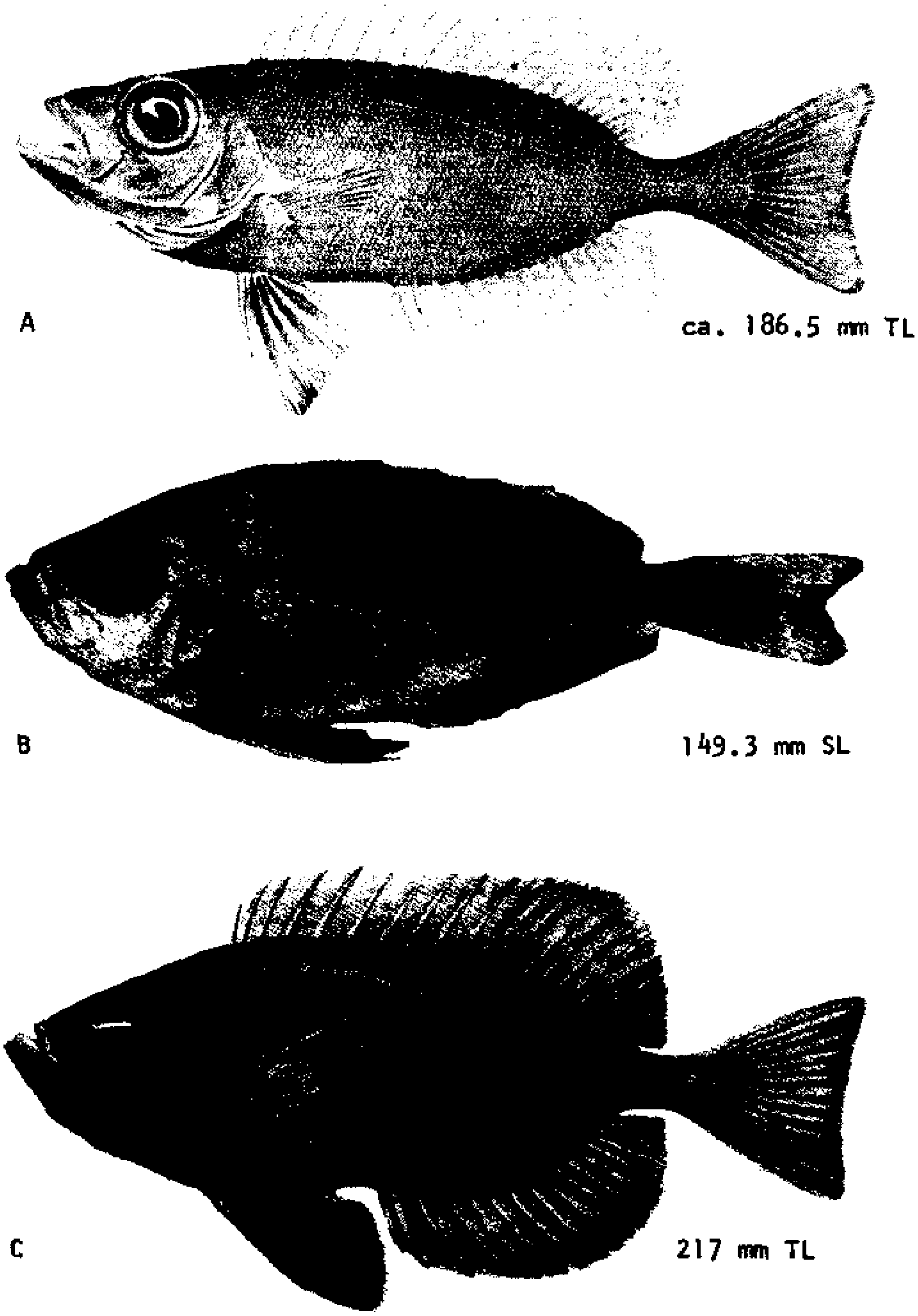

Fig. 82. *Priacanthus arenatus*, Bigeye. A. Adult, ca. 186.5 mm TL. B. Juvenile, 149.3 mm SL. C. Juvenile, 217 mm TL. (*A, Evermann, B. W., and M. C. Marsh, 1902: pl. 16. B, Caldwell, D. K., 1962: fig. 3. C, Böhlke, J. E., and C. C. G. Chaplin, 1968: 309.*)

Priacanthus cruentatus (Lacépède), Glasseye snapper

ADULTS

D. X, 13–14; A. III, 14–15; [3] C. 4+8+8+4; [12] lateral line scales 54–63; [1] mid-lateral scale rows 78–82,[6] scales above lateral line to base of 3rd dorsal spine 7, below lateral line to spinous anal origin 41; predorsal scales 50;[6] gill rakers 5–6+16–20 (totals 21–25); [6] vertebrae 10+13.[12]

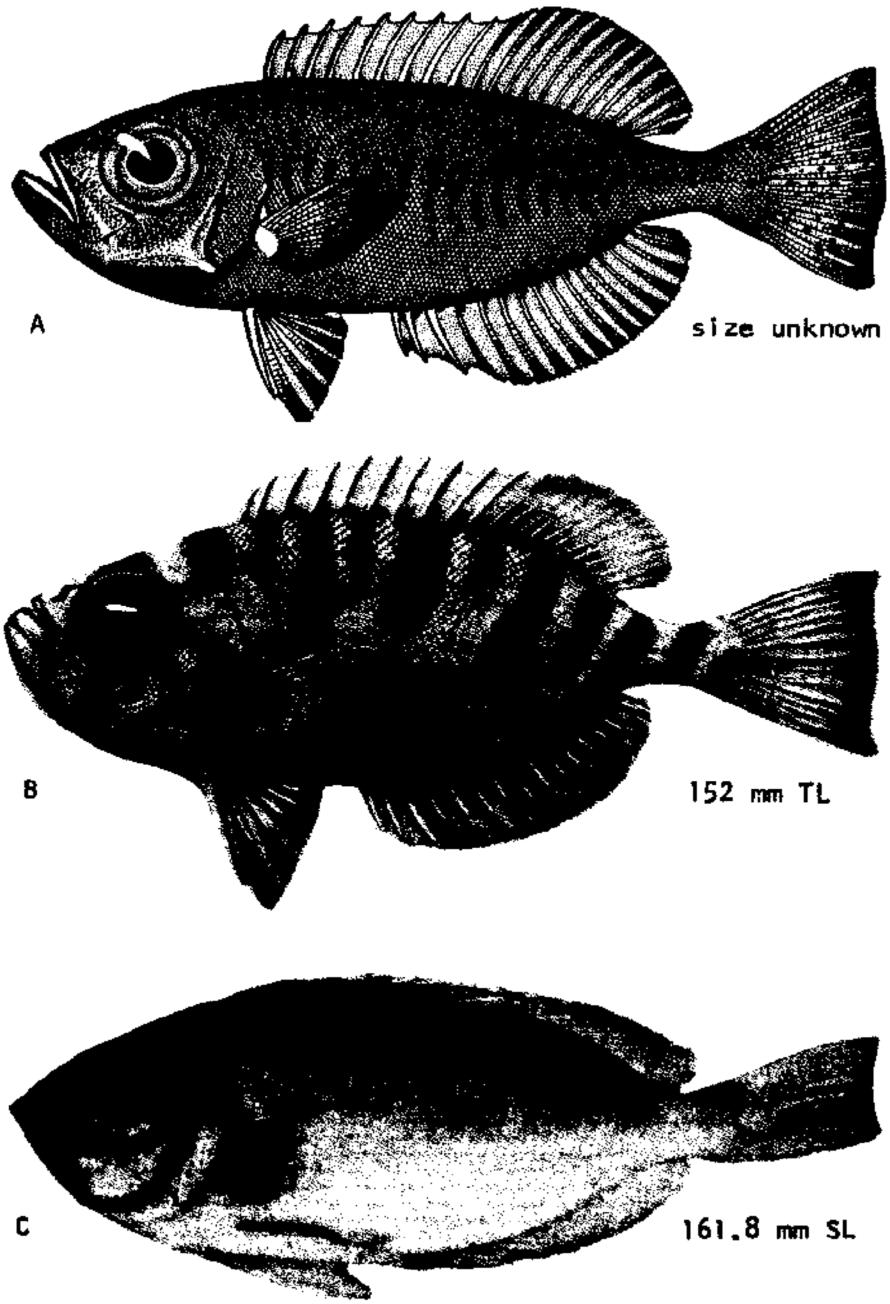

Fig. 83. *Priacanthus cruentatus*, Glasseye snapper. A. Adult, size unknown. B. Juvenile, 152 mm TL. C. Juvenile, 161.8 mm SL. (*A, Jordan, D. S., and B. W. Evermann, 1905: fig. 93. B. Böhlke, J. E., and C. C. G. Chaplin, 1968: 308. C, Caldwell, D. K., 1962: fig. 2.*)

Depth 2.5–3.6 times in SL; [1] eye 2 times in head.[3]

Body deep,[7] strongly compressed; [9] mouth large, oblique; roof of mouth with longitudinal ridges; maxillary extended nearly to middle of eye, teeth in jaws small, conic, those in front of jaw biserial; teeth also present on vomer and palatines.[8] Preopercular spine long, curved, serrate.[2,8] Eye noticeably large.[11] Dorsal and anal spines finely serrate.[3]

Pigmentation: Ground color rose,[3] reddish,[2] purple-red,[10] or silvery washed with rose, pink, or red [1,8] (although silver pigment may indicate juvenile specimens, JDH); dorsum brownish with 5–6 rosy blotches extending down sides to below lateral line; venter rosy; vertical fins with pale bases; [8] dorsal, anal, and caudal fins with rows of reddish spots; [2] caudal fin black-edged; pectoral fins rosy; pelvic fins rosy or dusky, black-tipped.[8]

Maximum length: Ca. 305 mm.[1]

DISTRIBUTION AND ECOLOGY

Range: Circumtropical.[1] In the western Atlantic from Narragansett,[5] Rhode Island and Bermuda [2] to Rio de Janeiro, Brazil, including the West Indies; [6,7] in the eastern Atlantic as far south as South Africa,[10] also St. Helena and the Canaries; [7] in the Pacific recorded from Baja, California; [13] Panama; the Galapagos; [4] and Hawaii.[6]

Area distribution: Coast of New Jersey.[5]

Habitat and movements: Adults—a shallow water reef fish; [1,4] sometimes washed ashore.[10] Minimum salinity, 30 ppt.[5]

Larvae—no information.

Juveniles—initially pelagic, then demersal (the change in habitat occurring simultaneously with change from blue and silver to red pigment).[6]

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

PREJUVENILES

Pigmentation: At 29.1 mm ground color of sides and belly silver; dorsum deep blue with 6 distinct royal blue saddles extending almost one-third distance down sides; lighter blue saddles between those extending only halfway as far down sides; several large, irregularly placed, dark blue spots on sides below saddles; pectoral and caudal fins transparent; pelvics, dorsal, and anal fins transparent and with royal blue spots of varying sizes. Eye gray, mottled with silver and with a black pupil.[6]

JUVENILES

Pigmentation: Assume red coloration shortly after arriving at bottom (possibly within a few hours).[6]

AGE AND SIZE AT MATURITY

No information.

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Pristigenys alta (Gill), Short bigeye

ADULTS

D. X,[1] 10–12 (usually 11);[6] A. III,[15] 9–11 (usually 10);[6] C. principal rays 16[6,15] (total rays 4+8+8+4); P. 16–19; V. I, 5; pored lateral line scales 31–39; mid-lateral scale rows 35–43 C; vertebrae 10+13;[26] gill rakers 6–9+17–21, total 23–30.[6,15]

Head 2.4[1]–3.0,[18] depth 1.7[1]–2.0[18] in SL; snout 3.85,[1] eye 2.0[18]–2.1, interorbital 1.85,[1] maxillary 1.8 in HL.[18]

Body short, deep,[1] ovate in outline, compressed;[3,21] head and snout very short; mouth relatively large, nearly vertical; maxillary to anterior margin of pupil; teeth pointed, in narrow bands on jaws, vomer and palatines, the outer series in jaws slightly enlarged; preorbital very narrow, serrate; preopercular margin serrate, with two slightly enlarged spines at angle.

Scales strongly ctenoid, reduced on head, present on cheeks and maxillary.[1] Dorsal fins continuous;[3] tips of soft dorsal reaching beyond caudal base;[18] caudal fin rounded[21] or truncate;[18] pelvic fins long, reaching beyond origin of anal;[1] pectoral fins small, about as long as eye.[18]

Pigmentation: Body red[1,3] to scarlet red;[8] iris gold;[18] dorsal fin red, spinous part edged with yellow, a few blackish dots on soft rays; anal fin red, edged with black; caudal pale with blackish reticulations; pectoral fins plain red; pelvic fins red at base, dusky or black distally.[1,3,15]

Maximum reported lengths: 279.4 mm TL,[1,20] 260 mm SL.[15]

DISTRIBUTION AND ECOLOGY

Range: Southport, Maine, to Horn Island, Mississippi;[11,15] also Bermuda, coast of Nicaragua, Cuba, Virgin Islands, and possibly the Bahamas;[6,7,12,15] a record from Brazil[2] is in error.[6]

Area distribution: Coast of New Jersey[15,29] including the Intercoastal Waterway at Atlantic City;[14] Ocean View, Virginia.[1]

Habitat and movements: Adults—a bottom dwelling, secretive,[15] coastal[12] species which does not normally occur in water of less than ca. 31 m[9] although sometimes inshore along beaches;[4] usually hidden in rock niches and dark crevasses, but may also form aggregations. Found over bottoms of coral, rock,[15] gravel, sand, shell, and gray mud. Maximum depth 201 m.[18]

Larvae—pelagic; at or near surface and in or near Gulf Stream, also probably transported by Gulf Stream.[15]

Juveniles—like adults, secretive but may form aggrega-

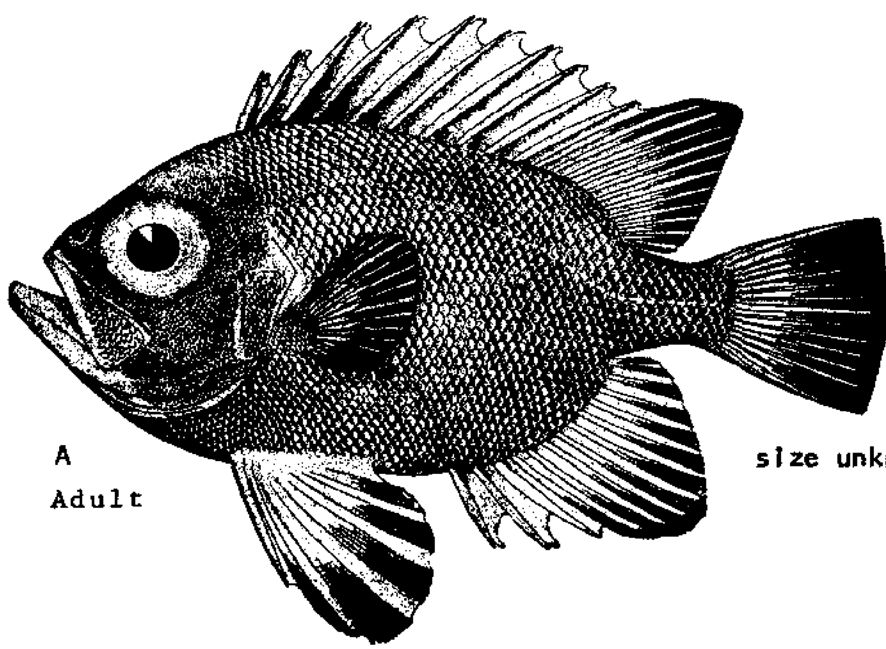


Fig. 84. *Pristigenys alta*, Short bigeye. A. Adult, size unknown. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 512.*)

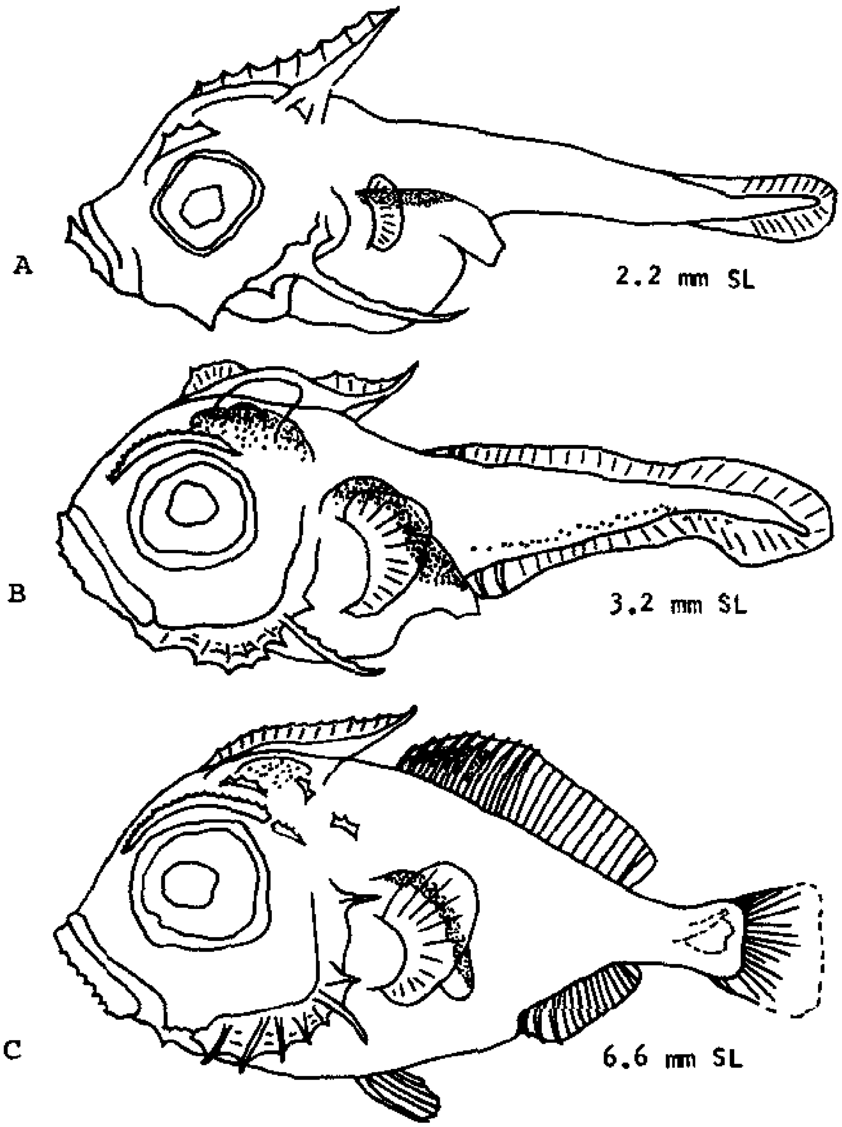


Fig. 85. *Pristigenys alta,* Short bigeye. A. Larva, 2.2 mm SL. B. Larva, 3.2 mm SL. C. Larva, 6.6 mm SL. (*A-C, Caldwell, D. K., 1962: figs. 8–10.*)

tions. Initially pelagic, and found offshore; [15] small individuals further offshore than larger ones.[20] Size at end of pelagic stage variable, but some up to ca. 58–60 mm.[15] Various depth/size relationships follow: a 28 mm specimen at 18 m; [11] a "prejuvenile" on bottom in water 31 m deep; [15] specimens 9.5–18.8 mm long offshore, but within the 180 m isobath; [30] specimens 12.4–19.9 mm long at 44 m in water 2377 m deep; pelagic "prejuveniles" from unspecified depths in water ca. 4572 m deep.[15] Juveniles as small as 29 mm also recorded inshore in surf,[3] tidepools,[3] and puddles on beaches.[5,8] There is a single record of a juvenile from the mouth of the Achusnet River, Connecticut.[10,22] Typically recorded over bottoms of rock and coral, and sometimes associated with oyster beds.[15]

May be transported by Gulf Stream [15] and apparently *move northward and inshore in fall;* [22,23] in New York area from September [24] to late October; [28] and in Massachusetts from August to November.[5]

SPAWNING

Location: Probably spawn where they spend their mature lives.[15]

Season: July (or possibly late June) to mid-September.[15]

Fecundity: Unknown.

EGGS

No information.

EGG DEVELOPMENT

No information.

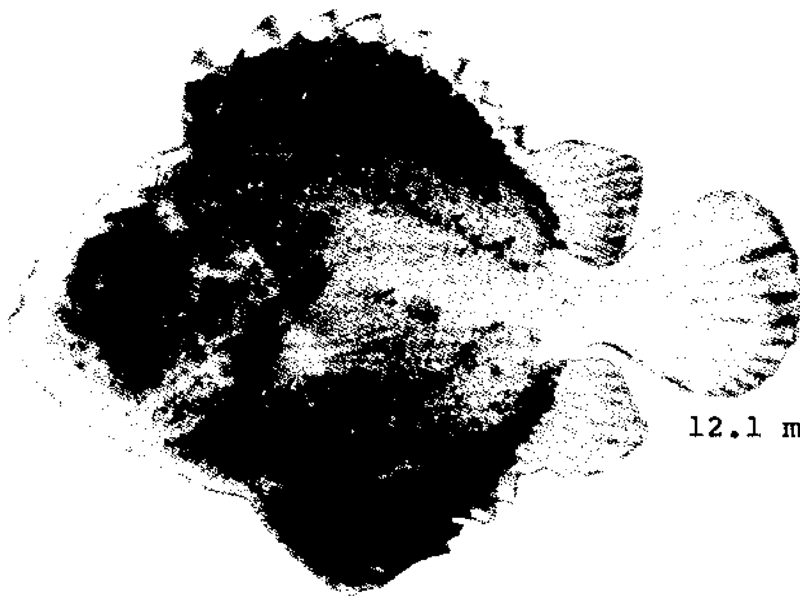
YOLK-SAC LARVAE

No information.

LARVAE

Size range described, 2.2–ca. 8.0 mm.

At 2.2 mm a single, medial, cranial crest with 8 serrations; a supraocular crest with three serrations over anterior half of supraocular region; a strong preopercular spine extending nearly to anal opening (this spine becoming progressively shorter in relation to head length as growth continues). At 2.4 mm cranial crest tilted further back toward body, number of serrations increased. At 2.6–2.7 mm serrations of cranial crest lost, crest flat against body except for upturned tip; supraorbital crest over entire eye and beyond, number of serrations increased. At 3.2 mm a secondary crest anterior to supraorbital crest. At

A  12.1 mm SL

B  15.0 mm SL

Fig. 86. *Pristigenys alta,* Short bigeye. A. Prejuvenile, 12.1 mm SL. B. Prejuvenile, 15.0 mm SL. *(A-B, Caldwell, D. K., 1962: figs. 11–12.)*

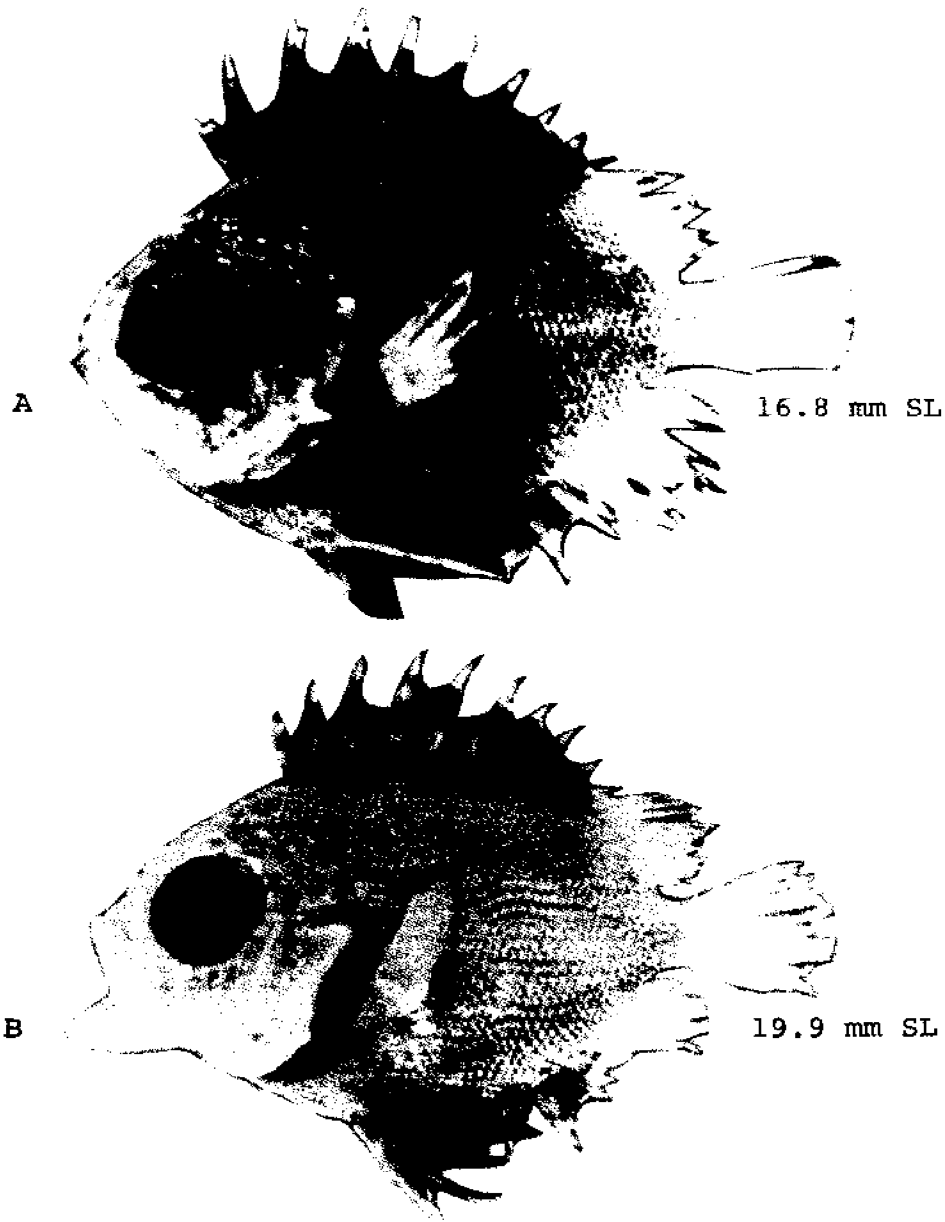


Fig. 87. *Pristigenys alta*, Short bigeye. A. Prejuvenile, 16.8 mm SL. B. Prejuvenile, 19.9 mm SL. (*A-B, Caldwell, D. K., 1962: figs. 13–14.*)

6.6 mm original crest entirely replaced by strongly serrated secondary crest; supraocular crest less prominent.[15]

External nostrils not discernible at 6.6 mm. At 2.7 mm full complement (6) of branchiostegal rays developed.[15] Anteriormost vertebrae ossified at 2.7 mm, all vertebrae at least partially ossified by 4.8 mm; hypural complex evident at ca. 3.5 mm; urostyle still oblique at 6.6 mm.[15]

Incipient caudal rays at 2.2 mm, ossification in caudal rays at 3.5 mm, full caudal ray complement and early segmentation at 4.4 mm. Incipient pectoral rays evident at 2.2 mm; beginning of ossification at ca. 3.5 mm, of segmentation by at least 6.6 mm; full pectoral ray complement at 5.3 mm. Incipient dorsal rays at 4.4 mm, segmentation of soft rays begun at about 6.6 mm. Incipient anal rays at 2.6 mm, first ossification at 3.5 mm, segmentation of soft rays at 5.3 mm. Pelvic buds evident at 3.9 mm, ossification of rays evident at 4.0 mm,

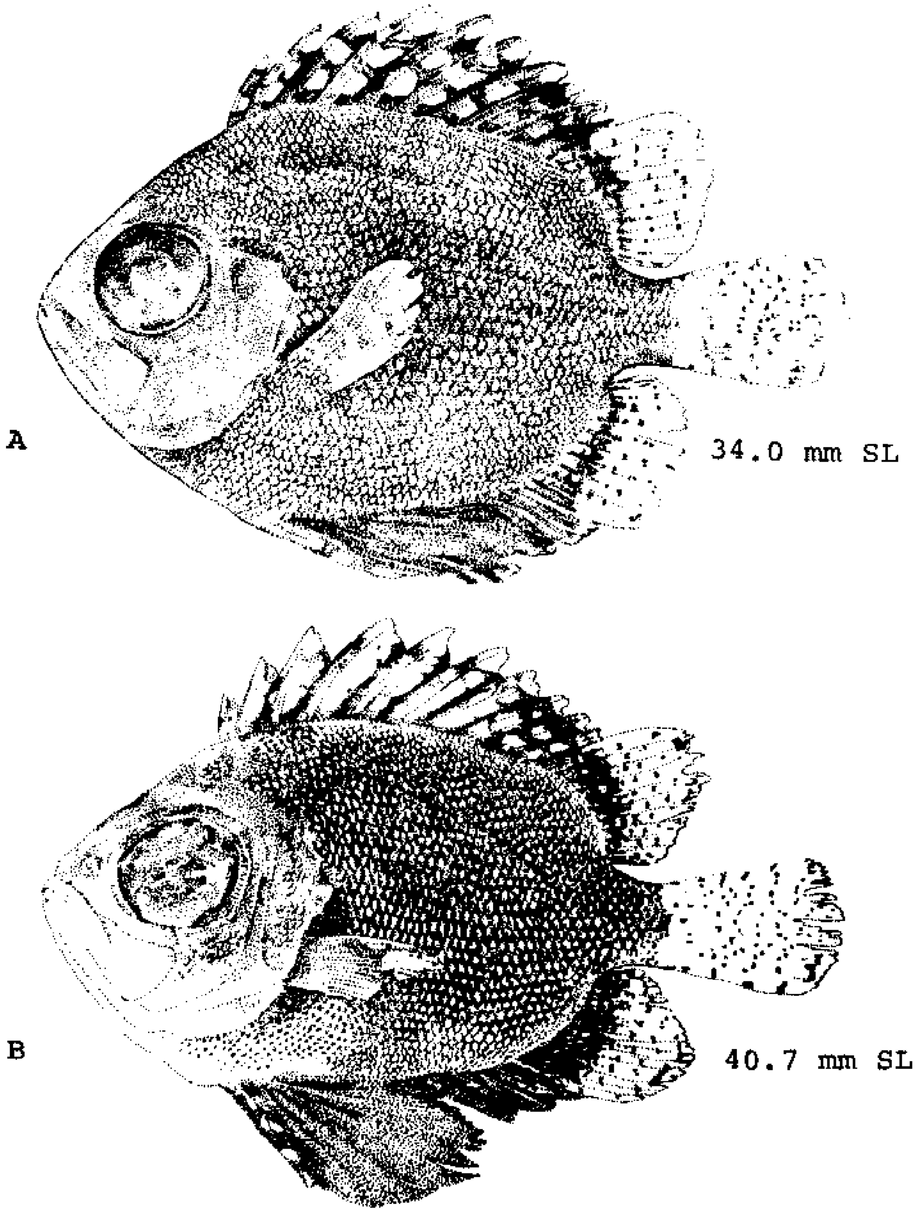


Fig. 88. *Pristigenys alta*, Short bigeye. A. Prejuvenile, 34.0 mm TL. B. Prejuvenile, 40.7 mm TL. (*A-B, Caldwell, D. K., 1962: figs. 15–16, Joan Ellis, delineator.*)

full complement of rays at 4.8 mm, earliest segmentation at ca. 6.6 mm.[15]

At 5.3 mm small patches of scales evident just above and in front of anus, and a small patch near the anterior end of the isthmus. At 6.6 mm scales over entire body except region just below and behind pectoral fin, on lower half of caudal peduncle, and near anal fin in area behind anus.[15]

Pigmentation: At 2.2 mm few scattered internal chromatophores in gut region; a dark region under cranial spine, small patch of pigment between eyes across surface of forebrain, fins immaculate.

At 2.4 mm a series of chromatophores along ventral midline of postanal region; light pigment at angle of preopercle.

At 2.6 mm basal two-thirds of preopercular spine pigmented; but pigment greatly intensified.

At 2.7 mm body generally darker (although individual chromatophores not evident); several dark spots along edge of isthmus; gill arches darkening; gut pigment increased; a single large chromatophore at anal opening.

At 3.2 mm few chromatophores on caudal finfold; chromatophores on optic lobes and braincase extended laterally.

At 3.9 mm pigment along inner edge of cleithrum.

At 4.0 mm chromatophores on caudal fin and ventral midline obliterated; those on preopercle, cleithrum, and gill arches reduced.

At 6.0 mm previously noted pigment entirely lost except at base of preopercle angle spine.

At 6.6 mm some specimens with numerous pigment spots on middle of membrane connecting first seven dorsal spines.[15]

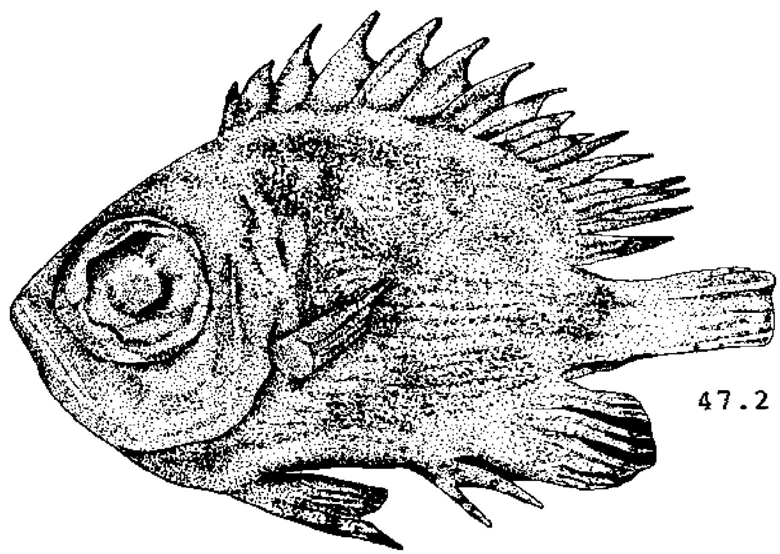
PREJUVENILES

Size range described, 8.2–ca. 65.0 mm.[15]

Proportions as times in TL at 50 mm TL: Head 3.4, depth 1.65;[19] relative size of eye at maximum at 35–65 mm.[15]

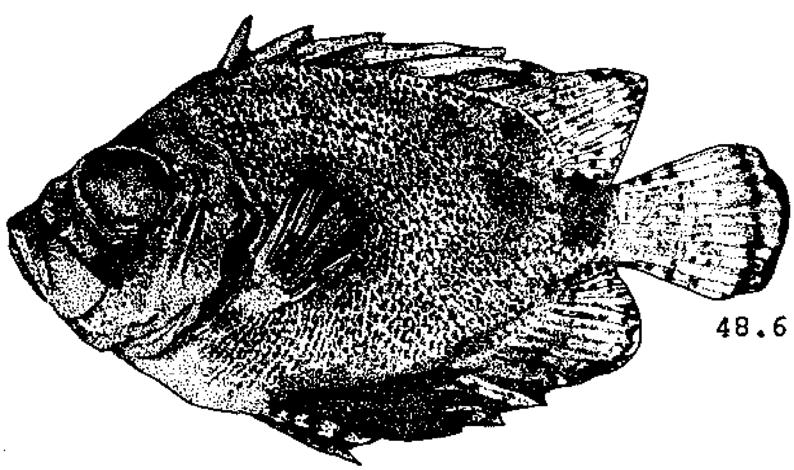
At 8.2 mm secondary cranial crest serrations weak, crest itself being absorbed by outgrowth of dorsal surface of head; supraocular crest more finely serrate. At 12.1 mm supraocular crest reduced. At 16.8 mm cranial crest evi-

A



47.2 mm SL

B



48.6 mm SL

Fig. 89. *Pristigenys alta*, Short bigeye. A. Prejuvenile, 47.2 mm SL. B. Prejuvenile, 48.6 mm SL. (A-B, *Caldwell, D. K., 1962: figs. 2, 17, Joan Ellis, delineator.*)

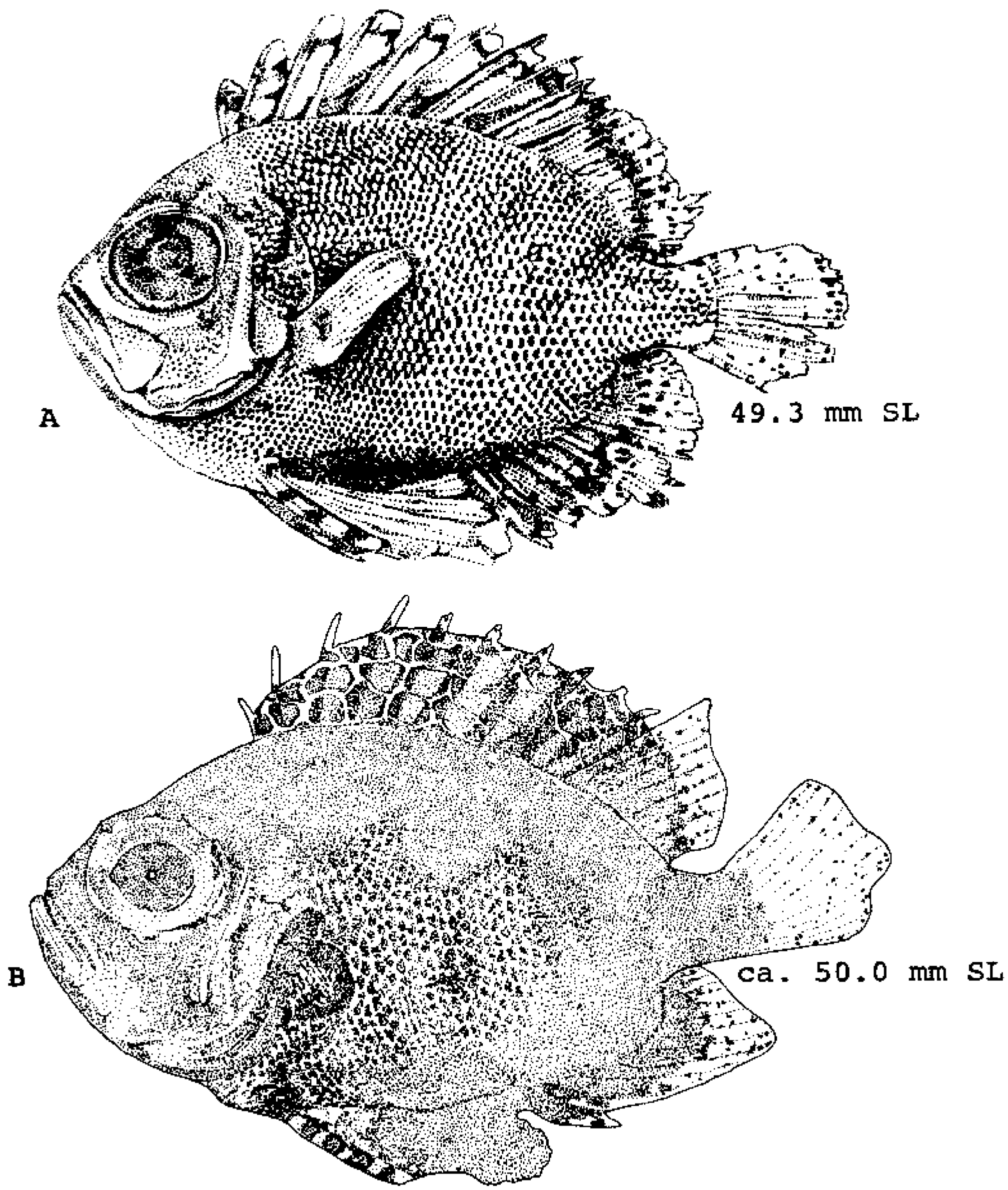


Fig. 90. *Pristigenys alta*, Short bigeye. A. Prejuvenile, 49.3 mm SL. B. Prejuvenile, ca. 50.0 mm SL. (*A-B, Caldwell, D. K., 1962: figs. 2, 24, Joan Ellis, Tamiko Karr, delineators.*)

dent only as row of weak serrations in midline of forehead, at 19.9 mm seen as outline only, and at 34.0 mm completely lost. At ca. 35 mm supraocular crest seen only as vague outline, lost at 40.0 mm.[15]

Paired nostrils complete at 8.2 mm [15] (Gill notes that at 28 mm the posterior nasal aperture is a long curved slit [17]); gill rakers well-developed at 8.2 mm; at ca. 35 mm a single row of widely spaced canines on outer edge of premaxillaries and dentaries.[15]

Segmentation of caudal rays completed at 8.2 mm; branching begun at 10.2 mm, complete at 16.8 mm. Segmentation and branching of pectoral fin rays at ca. 8.2 mm. Full complement of dorsal spines evident at 8.2 mm; segmentation of soft dorsal rays begun at ca. 6.6 mm, complete by at least 8.2 mm; branching of soft rays begun at 16.8 mm, complete between 20.0 and 34.0 mm. Full complement of anal spines at 8.2 mm, segmentation of anal soft rays complete at ca. 8.2 mm; branching of

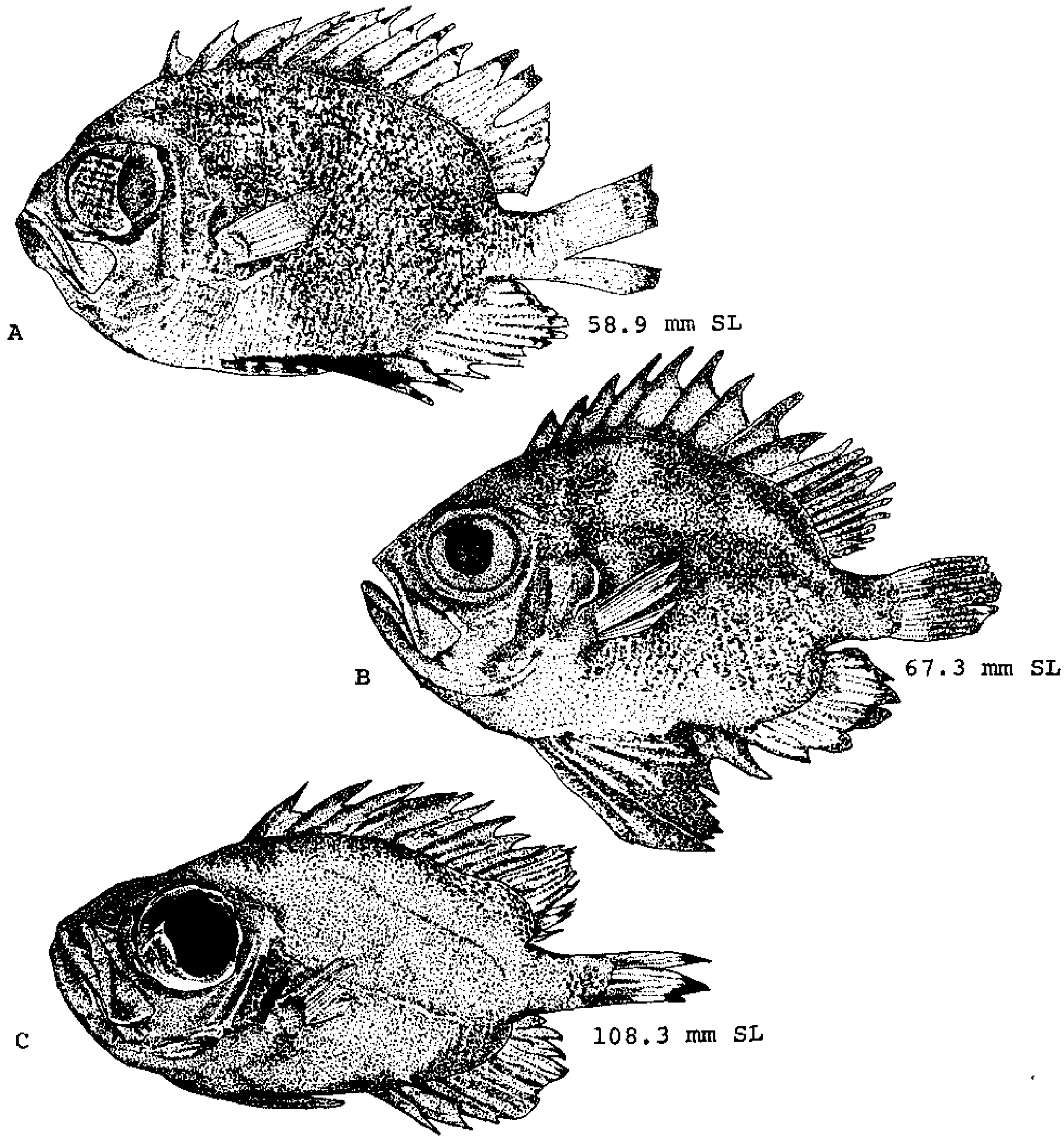


Fig. 91. ***Pristigenys alta,*** Short bigeye. A. Prejuvenile, 58.9 mm SL. B. Juvenile, 67.3 mm SL. C. Juvenile or adult, 108.3 mm SL. (***A-C, Caldwell, D. K., 1962: figs. 18–20, Joan Ellis, delineator.***)

soft anal rays begun at 15.0 mm, completed at 16.8 mm. Pelvic ray segmentation complete and branching started at ca. 8.2 mm; branching completed at 8.7 mm. Lateral line scales evident at ca. 25.0 mm.[15]

Pigmentation: Early prejuveniles may be bluish or silvery in life,[15] although a 22 mm specimen has been described as reddish with three clear-cut dark bars,[19] and a 28 mm specimen was orange-red.[11] In general early prejuveniles have immaculate soft dorsal and anal fins; later prejuveniles have soft parts of vertical fins spotted, with or without a black edge.

At 8.2 mm body covered with small dark chromatophores, internal pigment obscure; ventrals with scattering of small dark chromatophores along rays and connecting membranes; pigment evident on anal; entire spinous dorsal pigmented, except tip.

At 10.2 mm entire external surface darkened; region of future lateral line marked with many sharply defined dark spots, above which is a series of 10 evenly spaced larger dots; pelvic with immaculate tips, otherwise completely covered with dark pigment; spinous dorsal very dark.

At 12.8 mm sometimes with 3 or 4 bars across pelvic spine.

At ca. 12.0–12.1 mm clear unpigmented disc-shaped areas on spinous dorsal forming row of spots parallel to base of fin; pigment also developed along base of soft dorsal.

At 15.0 mm isolated dark spots again evident in region of cleithrum; tips of ventrals covered with pigment; second row of light spots on spinous dorsal distal to first; pigment migrating along dorsal soft rays.

At 16.5 mm soft dorsal may still be immaculate.

At 16.8 mm basal parts of ventrals begin to lose pigment (although still evident in some specimens up to 50 mm); spinous dorsal now with third row of light spots, and pigment developing on membranes of anteriormost soft dorsal rays.

At 20–30 mm skin and scales covering caudal base lighter, dark chromatophores begin to outline the scale pockets and the scales themselves just anterior to their cteni.

At 23.2 mm small dark spots arranged in irregular vertical rows on caudal rays.[15]

At ca. 28 mm soft dorsal and anal more or less dotted with black; pectoral fins entirely black.[17]

At 34 mm three or four incomplete obscure vertical bars evident; three rows of unpigmented spots on spinous dorsal, and fourth row beginning to form at base of some spines; scattered chromatophores on soft dorsal rays forming irregular rows parallel to base of fin; several light spots in pigment mass at base of soft dorsal; anal with two rows of light spots.

At 34.5–65.2 mm caudal fin speckled, tips of rays initially plain but with pigment migrating distally along rays to form black band of varied intensity proximal to light tips.

At 48.6 mm row of ca. 10 large dots above lateral line still evident; spinous dorsal essentially unpigmented except for scattered chromatophores near anterior and posterior edges of membrane; soft dorsal with only scattered chromatophores on membrane and bands of pigment on rays.

At ca. 50 mm on intense pattern of 3 or 4 bars on ventral spine.

At 58.9 mm scales appear to have dark centers; all traces of light spots on spinous dorsal gone, basal half of soft dorsal essentially immaculate.[15]

A 28 mm specimen described (apparently in life) as orange-red with 12 black blotches immediately above lateral line; spiny dorsal with 2 rows of orange spots; ventral spine with 2 orange spots; iris with four white spots.[11]

JUVENILES

Minimum size described, 63.2 mm.[15]

At 70 mm two enlarged preopercular spines at angle of preopercle; pelvics much longer and body much deeper than in adult.[1]

Pigmentation: At 63.2 mm caudal fin immaculate, except for dark band at border.

At ca. 65 to 67.3 mm pelvic fin pigment concentrated almost entirely on membrane; dorsal fin with anteriormost soft rays black-tipped, otherwise essentially immaculate.

At ca. 75 mm and larger, ventral spine immaculate, barred pattern no longer evident.[15]

AGE AND SIZE AT MATURITY

A specimen 180 mm long was presumably nearly adult.[15] Age at maturity, unknown.

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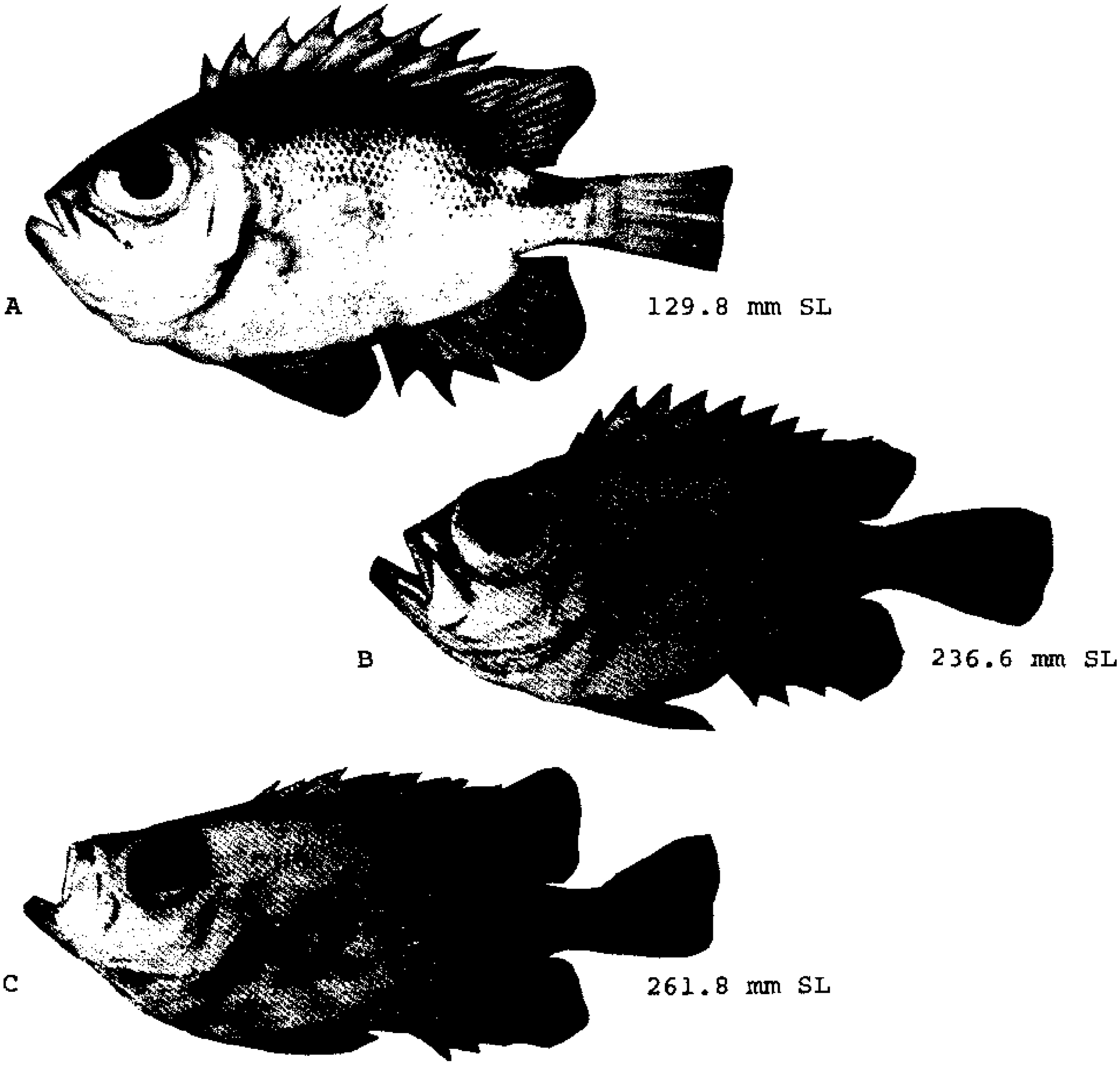

Fig. 92. ***Pristigenys alta***, Short bigeye. A. Juvenile or adult, 129.8 mm SL. B. Juvenile or adult, 236.6 mm SL. C. 261.8 mm SL. (*A-C, Caldwell, D. K., 1962: figs. 21–23.*)

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Acantharchus pomotis
Ambloplites rupestris
Centrarchus macropterus
Enneacanthus chaetodon
Enneacanthus gloriosus
Enneacanthus obesus
Lepomis auritus
Lepomis cyanellus
Lepomis gibbosus
Lepomis gulosus
Lepomis macrochirus
Lepomis megalotis
Lepomis microlophus
Micropterus dolomieui
Micropterus salmoides
Pomoxis annularis
Pomoxis nigromaculatus

sunfishes
Centrarchidae

FAMILY CENTRARCHIDAE

The sunfishes, of which there are two subfamilies, nine genera, and 30 species, originally occurred only in North America between extreme northeastern Mexico and southern Canada. The family was rare west of the Rocky Mountains, and only one species, *Archoplites interruptus*, occurred naturally in California. Centrarchid fishes have now been widely introduced throughout the world. They are essentially freshwater fishes, seldom entering brackish water, and are found mainly in warm, shallow waters of lakes, ponds, and slow moving streams.

In these fishes the body is laterally compressed; villiform teeth are present on the jaws, vomer, palatines, and tongue of most species; the gill membranes are separated; there are five to seven branchiostegal rays; the spinous and soft dorsal fins are joined to varying degrees into a single fin; there are three to nine anal spines; and the caudal fin is forked or rounded. In the subfamily Centrarchinae a lateral line is present (although sometimes incomplete) and suborbitals are present. In Elassomatinae there are no suborbitals and no lateral line.

Nest building and guardianship of the eggs and young are important behavioral characteristics of the family. Most sunfishes construct nests by scooping out shallow depressions in the substrate. Nesting is frequently colonial, particularly among members of the genus *Lepomis*, and huge numbers of fish may be involved in nesting activities. In *Lepomis humilis*, for example, one colony contained 960 nests. Members of the genus *Enneacanthus* usually spawn in or close to aquatic vegetation. *Elassoma zonatum*, the pigmy sunfish, may clean a nest or simply attach its eggs to aquatic vegetation as does *Elassoma evergladei*. Among the larger sunfishes, *Archoplites interruptus* does not construct a nest, but simply deposits its eggs over boulders. *Lepomis cyanellus* and *Pomoxis annularis* may sometimes fail to construct nests, while the colonial nest builder *Lepomis auritus* sometimes spawns in the nests of other species.

The male parent guards the eggs and young. Soon after hatching the young rise from the nest and are then herded in a compact school by the male. This behavior is most strikingly developed in members of the genus *Micropterus*.

Eggs of the regional sunfishes vary in diameter from 0.8 (in *Lepomis gibbosus*) to 2.8 mm (in *Micropterus dolomieui*) and are demersal and adhesive. In most the chorion is thick and striated, the perivitelline space is quite narrow, and there is a single large oil globule. In *Enneacanthus* there are a number of oil globules of various sizes.

At the time of hatching, sunfish larvae are poorly developed. They lack pectoral fins and pigment, the mouth is not formed, and there is frequently a prominent choroid fissure. The dorsal finfold is typically low and does not extend forward to the head. In recently hatched larvae the yolk sac is large and oval. The position of the oil globule is variable, although it is typically in the posterior half of the yolk mass. The anus is usually in the forward half of the body, but its position can vary from three-tenths to nearly three-fifths the distance to the end of the tail. In most species pigment is first evident along the ventral edge of the tail.

Anjard (1974) has described and illustrated differences between the larvae of the three most important centrarchid genera of the Mid-Atlantic Bight (fig. 93). In *Micropterus* the body is distinctly deeper than in *Lepomis* and *Pomoxis*, the gut is massively coiled, and the anus is conspicuously behind the gas bladder and located at about the middle of the body length. In *Lepomis* the gut is S-shaped, the anus is well posterior to the air bladder and about at mid-body, and there is always a characteristic pigment spot above the anus. In *Pomoxis* the body is slender, the gut is tightly coiled, the anus is under or only slightly behind the posterior end of the gas bladder; and the preanal length is much less than the postanal length. In *Enneacanthus* the body is very slender, and the anus far forward at a point about one-third the distance to the tip of the tail.

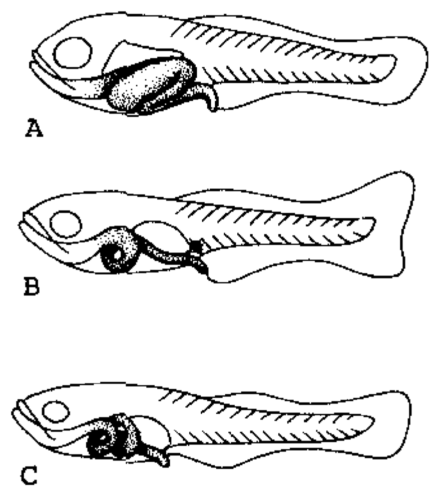

Fig. 93. Identifying characteristics of larvae of various genera of centrarchid fishes. A. *Micropterus*, gut coil massive, body heavy, anus noticeably posterior to gas bladder. B. *Lepomis*, gut long, S-shaped; a conspicuous melanophore above anus; vent noticeably behind gas bladder. C. *Pomoxis*, gut tightly coiled, preanal length conspicuously less than postanal length, anus under and slightly behind air bladder. *(A-C, Anjard, C. A., 1974: 179.)*

Acantharchus pomotis (Baird), Mud sunfish

ADULTS

D. XI to XII, 10 [4]–12; A. IV to VI, 9–12; [12] P. 14; V. I, 5; [10] scales in lateral line 43, in transverse series 6+12,[4] 5 rows on cheek; [9] gill rakers upper limb 5, 2 on lower.[12]

Body oblong, not much compressed; [6] maxillary extended to posterior third of eye; [6] scales cycloid; caudal fin rounded.[4]

Pigmentation: Ground color blackish green [4] or dark olive green with 3 [10] to 6 [4] (although several drawings suggest as many as 7 [4]–10 [14]) irregular bands of blackish [13] or dull greenish yellow on flanks and, occasionally, cloudy spots of golden green; about 3 dark olive bands on head,[10] the lowermost passing across maxillary and around front of lower jaw; [13] a deep black blotch on gill covers.[4] Iris purplish brown, cornea olive green. Fins dark greenish olive [10] or opaque blackish, except pectoral fins which are light olivaceous. Spines of pelvic fins unpigmented.[4]

Maximum length: 300 mm.[4]

DISTRIBUTION AND ECOLOGY

Range: Coastal plain from southern New York to Florida.[5,6,7]

Area distribution: Coastal areas of Virginia,[14,15] Maryland,[7] and New Jersey; [1] also Delaware River.[17]

Habitat and movements: Adults—sluggish streams,[7] creeks, rivers,[3] and ponds in turbid, brownish water (which may sometimes be filled with suspended matter) [8] over bottoms of organic debris, muck, sand and muck, gravel and sand, and rock.[11] Appear to be largely nocturnal, hiding by day under banks or submerged logs and stones; [1,7] sometimes burrow in mud [10] or hide in weeds, assuming perpendicular head-down position.[3] Apparently only in freshwater, but recorded by Cope from sluggish streams of the tidewater region.[8]

Larvae—no information.

Juveniles—"very young" in schools.[2]

SPAWNING

Location: A single nest reported near shore in a cranberry bog in water 305 mm deep over bottom of mud and sand; nest itself 305 mm in diameter and surrounded by spatterdock.[16]

Season: Reported for June 1 in New Jersey.[16]

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Minimum size described, ca. 47 mm.[14]

Eye proportionately larger in "young" than in adult.[12]

Pigmentation: In a specimen of *A. p. pomotis* from New Jersey ca. 48 mm long, lateral pattern essentially adult-like; dorsal and anal fins with chromatophores arranged in small discrete blotches, those of caudal fin in indefinite bands. In a series of *A. p. mizelli* from Georgia longitudinal bands often broken into series of indefinite blotches; pigment in dorsal, anal, and caudal fins highly variable.[14] In a "half-grown" specimen of unknown subspecies pattern adult-like.[4]

AGE AND SIZE AT MATURITY

No information.

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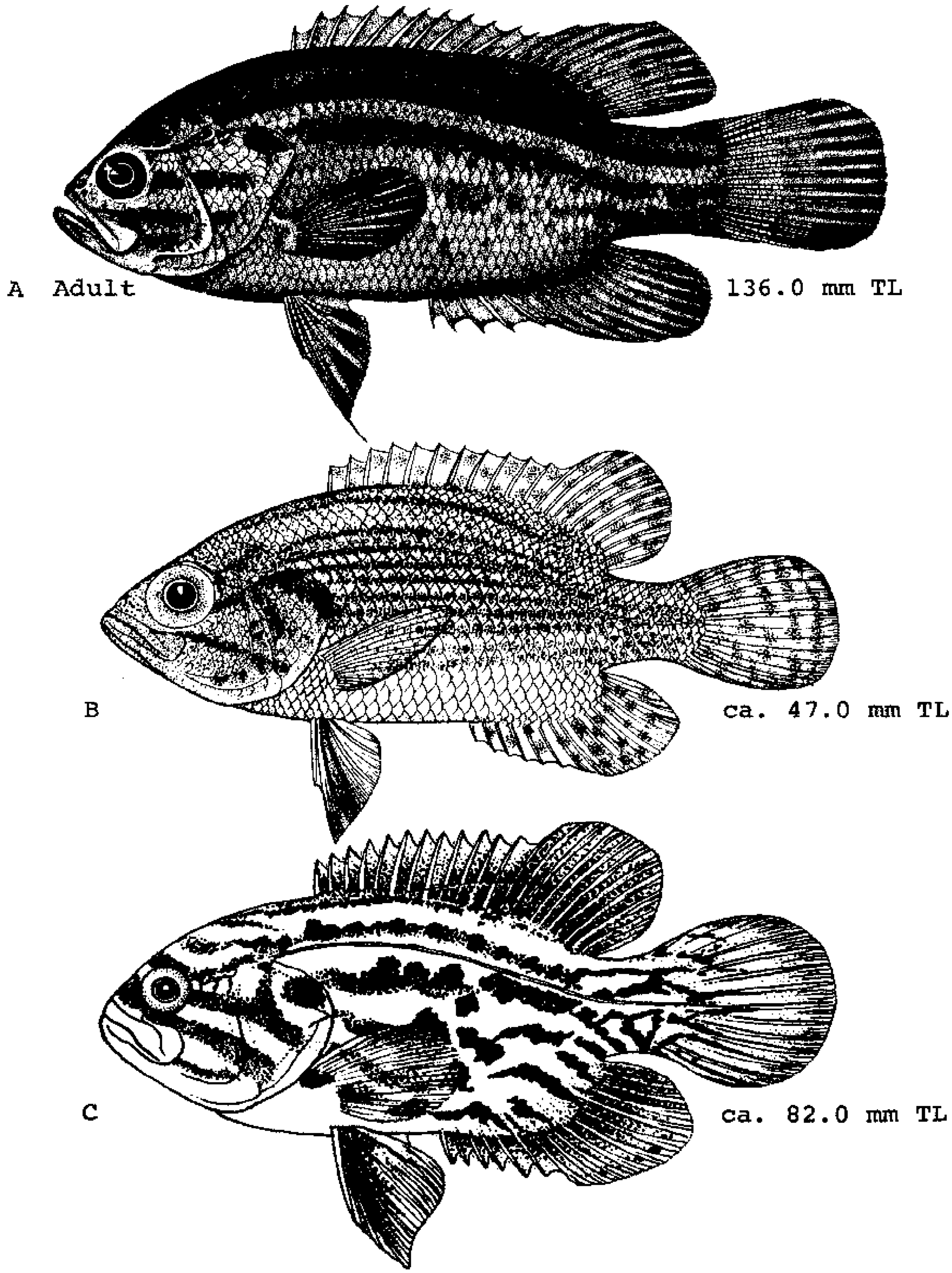

Fig. 94. *Acantharchus pomotis*, Mud sunfish. A. Adult, 136.0 mm TL. B. Juvenile, ca. 47.0 mm TL (specimen from New Jersey). C. Juvenile, ca. 82.0 mm TL (specimen from Georgia). (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 418. B, C, Fowler, H. W., 1945: figs. 238, 242.*)

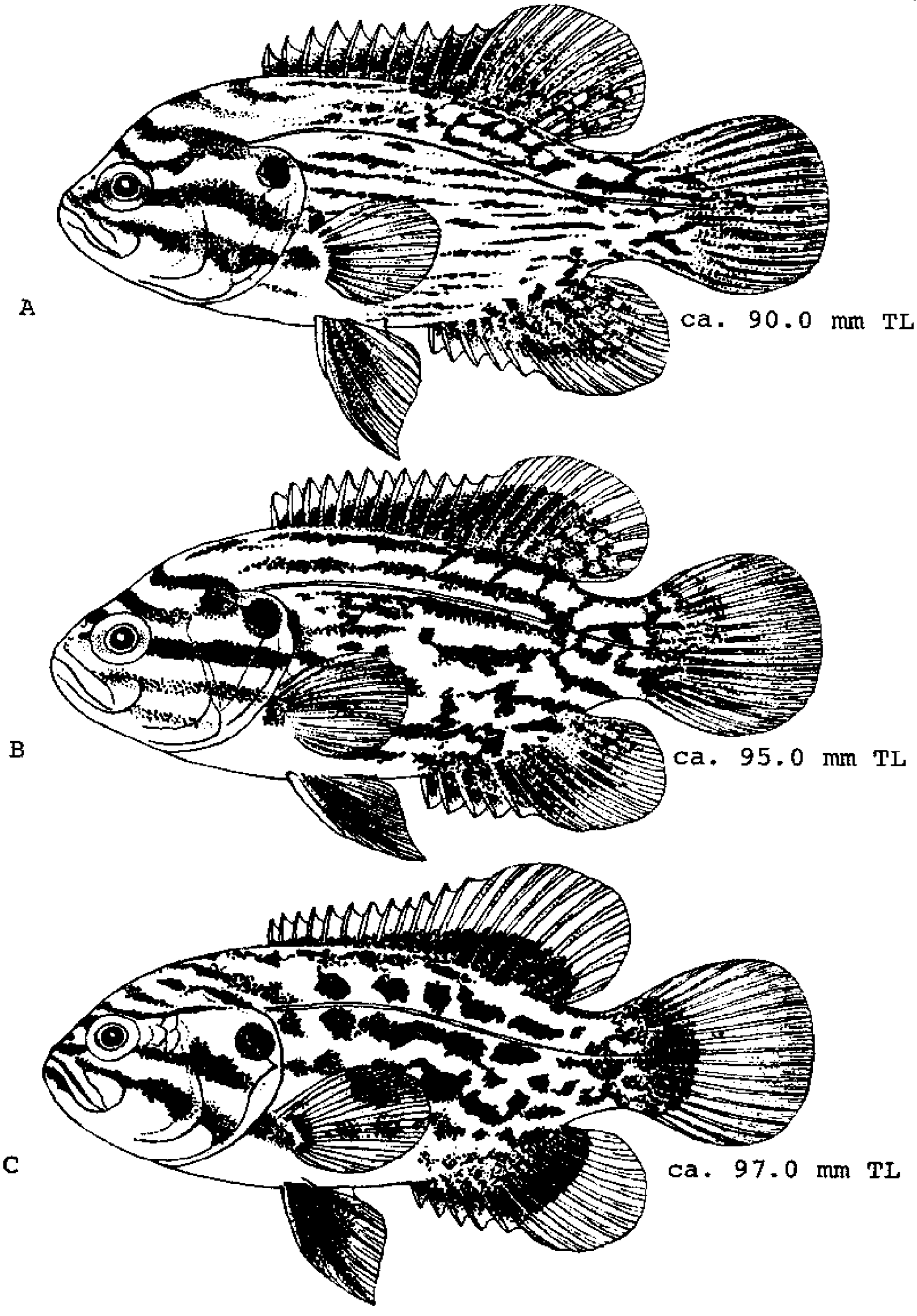

Fig. 95. ***Acantharchus pomotis***, Mud sunfish. A. Juvenile, ca. 90.0 mm TL. B. Juvenile, ca. 95.0 mm TL. C. Juvenile, ca. 97.0 mm TL (all specimens from Georgia). *(A-C, Fowler, H. W., 1945: figs. 243–245.)*

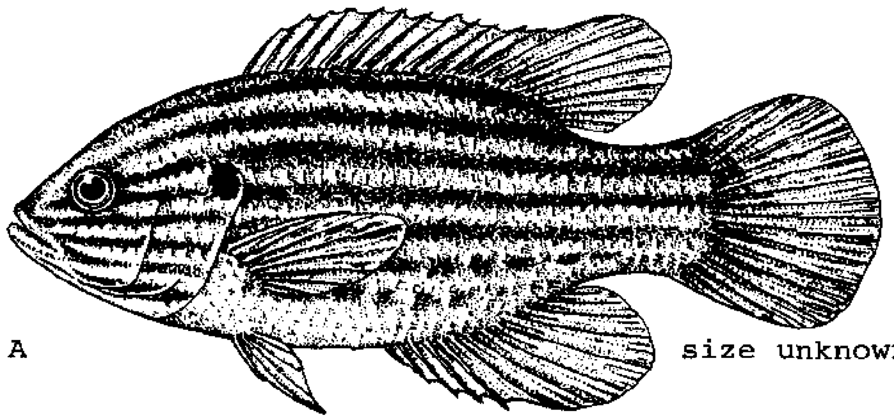

Fig. 96. *Acantharchus pomotis*, Mud sunfish. A. Juvenile, "half-grown," size unknown. (*A, Sterba, G., 1967: fig. 984.*)

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Ambloplites rupestris (Rafinesque), Rock bass

ADULTS

D. X [13] to XII, 10–12; [9] A. V to VII, 9–11; [13] P. 12–14; V. I, 5; scales in lateral line 37–51; [30] above lateral line 6 [15]–10; [16] below lateral line 11 [13]–16,[16] on cheek 6–8; [9] gill rakers upper limb 4,[30] lower limb 7 [9]–12; branchiostegals 5–6; pyloric caeca 9; vertebrae 29–30 [30] (but also stated as 14 + 18 [27]).

Proportions as percent TL: Greatest depth 31.8–36.7, depth of caudal peduncle 12–14. Proportions as percent HL: eye 26.7–40.9, maxillary 33.3–45.5.[30] Head 2.75 times in length.[21] Longest anal spine about half length of spinous anal; [6] anal base about one-half length of dorsal base.[17]

Body oblong,[14] *rather deep, compressed;* [13] *mouth terminal,*[30] large, directed obliquely upward; [13] maxillary to middle of pupil; [27] scales ctenoid; [13] caudal fin emarginate.[14]

Pigmentation: Light olive,[27] dark slate, or olive green with bronze or coppery reflections above; back crossed with 4–7 dark broad saddles; [4] upper sides olivaceous [9] or brassy olivaceous; [15] sides below lateral line lighter; [4] sides irregularly mottled with black, or with dorsal saddles extended to lateral line; a dark spot or bar on each lateral scale, these forming interrupted black lateral stripes; [9,13,15,27] venter white, brassy or brassy white,[4] white dusted with brassy,[31] or bluish white with dark dots; top of head dark green; sides of head brassy with dark bar downward from eye; opercular spot black,[9,27] gold-rimmed in males; [13] eye described as red [6,24] or golden overlaid with crimson.[23] Dorsal, anal, and caudal fins delicate greenish,[13] olivaceous yellow,[27] or brownish yellow [13] and with dark mottling [9] and, usually, black margin; [4] vermiculations of soft dorsal fin often forming ocelli; pelvic and pectoral fins transparent, olive [4] or pale lemon.[27] In clear water boldly marked with black and bronze; in turbid water often yellow-bronze and lacking black markings. Breeding males blackish; [4] pectoral fins blackish in breeding males, brownish in breeding females.[13]

Maximum length: About 346 mm.[10]

DISTRIBUTION AND ECOLOGY

Range: Southern Canada from Quebec to southeastern Saskatchewan; south through the Dakotas, Nebraska, southern Kansas, northeast Oklahoma, central Arkansas, Louisiana,[30] and Texas; [17] east to Florida panhandle; northward, generally west of Appalachians to Vermont and Quebec.[15,30] Introduced on the Atlantic slope,[17] Washington state,[10] Colorado, and Wyoming.[30]

Area distribution: Introduced in Patuxent River and Rock Creek in 1894,[28] now in all major tributaries of Chesapeake Bay; [3] New Jersey.[26]

Habitat and movements: Adults—a schooling species [23] found in relatively shallow waters of lakes,[1,2] ponds,[23] rivers,[25] creeks,[2] and streams of moderate gradients [4] over bottoms of rock,[2,9,15,30] gravel, or boulders; [4] usually associated with aquatic vegetation [2,7,17,31] such as bulrushes,[34] *Potomogeton*,[25] and water willow; [4] also in deep holes,[25] around stumps, logs, and roots, and in shady places under high banks and projecting rocks; [2,25] prefer clear rocky streams; [9] least abundant in muddy lakes; [2] hibernate in summer haunts under leaves and debris or among roots and water willows.[4] Apparently nonmigratory; remain in very limited area, and unlikely to range through more than a mile of stream in the course of a two year period.[32] Maximum recorded salinity, 0.03 ppt,[37] but also recorded from "off Worton Point, Md." [3] where salinities are probably somewhat higher (JDH). Maximum depth, 21.3 m.[11] Maximum temperature, unknown, but maximum recommended for aquarium stock 20 C.[35]

Larvae—among plants in bottom of nest; [34,35] rise from nest in a few days.[2,22]

Juveniles—when one month old along shore in grass.[36] Young of unspecified age in shallow water, over algae covered stones along shore, in dense aquatic vegetation, and in lower courses of streams.[1,2,6,8,18,30,33] In lakes move from littoral to limnetic zone as development proceeds.[46]

SPAWNING

Locations: Occurs in lower reaches of rivers entering lakes; [22] also swampy bays [2] and gravel shoals [30] in water "a few inches" [2] to 305 mm deep (but at 1.2 m in aquarium studies) [5] over bottoms of sand, gravel,[2,27] marl [6,34] or exposed roots.[20] In some cases there is apparently no definite nest; [34] otherwise nest a circular depression varying in diameter from 200 mm [2,22] to 1.1 m,[20] and with maximum depth (rim to bottom) of about 51 mm.[34] Nests often close together [30] among rushes,[2,27] near clumps of weeds,[20] or beside sticks, stakes, rocks, or similar objects.[2,27] May spawn in nests of other species.[20]

Season: In Texas spawning begins in March; [19] in North Carolina takes place in "spring"; [21] in Indiana May 15 to June 15; [2,27] in Lake Erie May and June; [1] in Michigan May 28 to July 13; [20] in Canada probably in June; under aquarium conditions July 11 to July 17.[30]

Time: Under aquarium conditions before 0900 hours and after 1500 hours.[30]

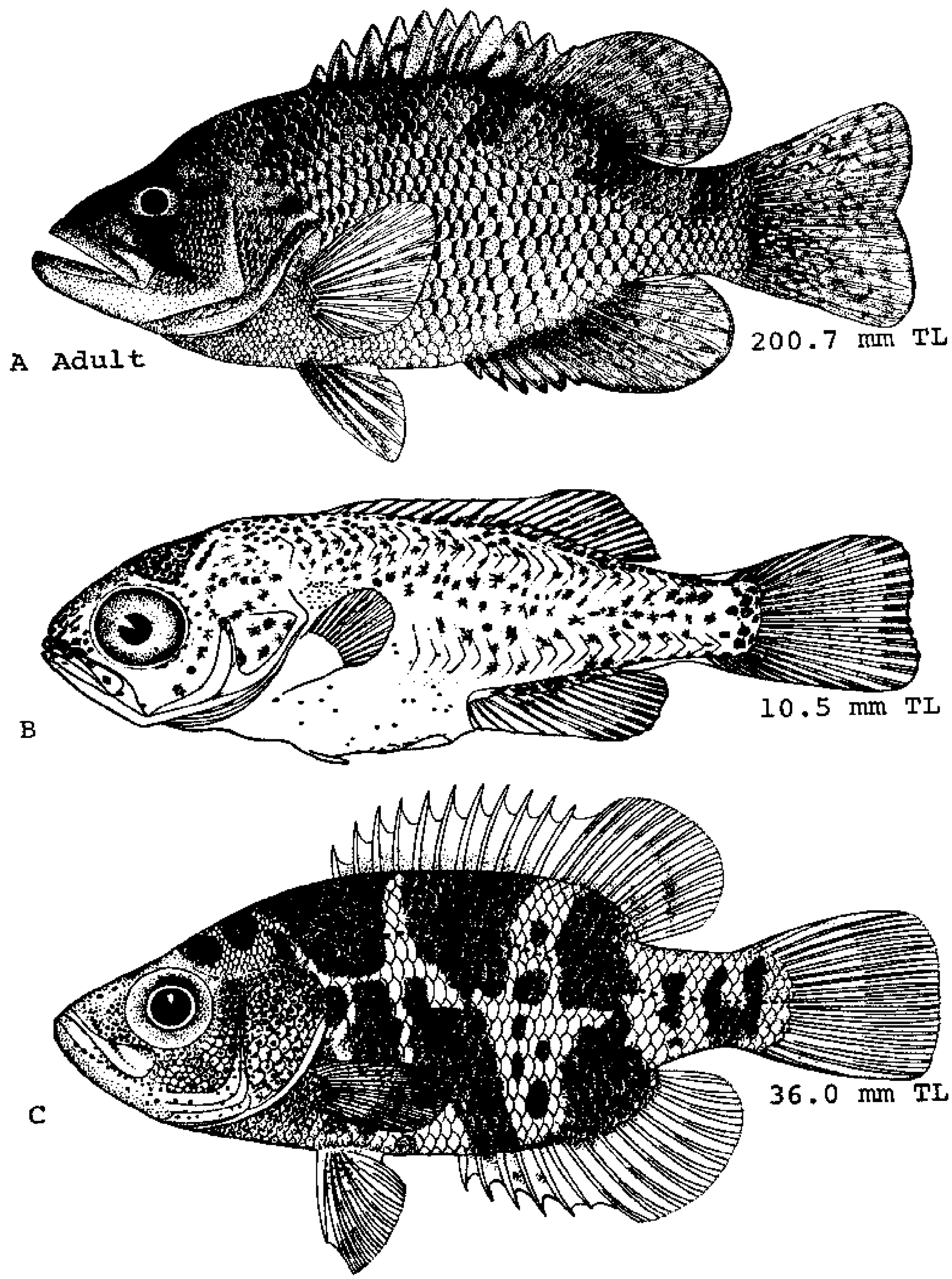

Fig. 97. *Ambloplites rupestris,* Rock bass. A. Adult, 200.7 mm TL. B. Larva, 10.5 mm TL. C. Juvenile, 36.0 mm TL. (*A, Trautman, M. B., 1957: fig. 128. B, Fish, M. P., 1932: fig. 124. C, Fowler, H. W., 1945: fig. 239.*)

Temperature: Range 15.6–21.1 C.[30]

Fecundity: 3000–11,000; [30] reported average 5000.[9] Number of fry per nest 344–1756, average 796.[20]

EGGS

Location: Attached to aquatic vegetation and roots in nest.[34,36]

Fertilized eggs: Adhesive [30] and about the size of small shot.[27]

EGG DEVELOPMENT

Incubation period at 20.5–21.0 C, 3–4 days.[30]

YOLK-SAC LARVAE

No information.

LARVAE

A single specimen described, 10.5 mm TL.

At 10.5 mm TL, myomeres 13 + 18.[1]

Snout vent length 47.6% TL; HL 29.5% TL; eye diameter 35.5% HL; greatest depth 30.3% TL.[1]

Body oblong, compressed; caudal peduncle stout; mouth terminal, oblique; maxilla past vertical from anterior margin of pupil.[1]

Pigmentation: Body and head with large stellate melanophores, especially on tip of both jaws, over snout and top of head, and in heavy dorsal and ventral series along margins of body and around fins; abdomen lighter than rest of body, but with few small chromatophores; chromatophores developed on dorsal, caudal, anal, and pectoral fins, usually near their bases; small chromatophores on dorsal surface of gas bladder.[1]

JUVENILES

Minimum size described, 51 mm.

Pigmentation: At 51 mm, sides with general black marbling; saddle marks of adult inconspicuous by day, well-developed at night. Young with irregular bars and blotches of black [24,25] or brown.[27]

AGE AND SIZE AT MATURITY

Age group II reported as mature although these fish would not have spawned until end of 3rd full year of life; males, 89 mm, females 89 mm.[29]

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Centrarchus macropterus (Lacépède), Flier

ADULTS

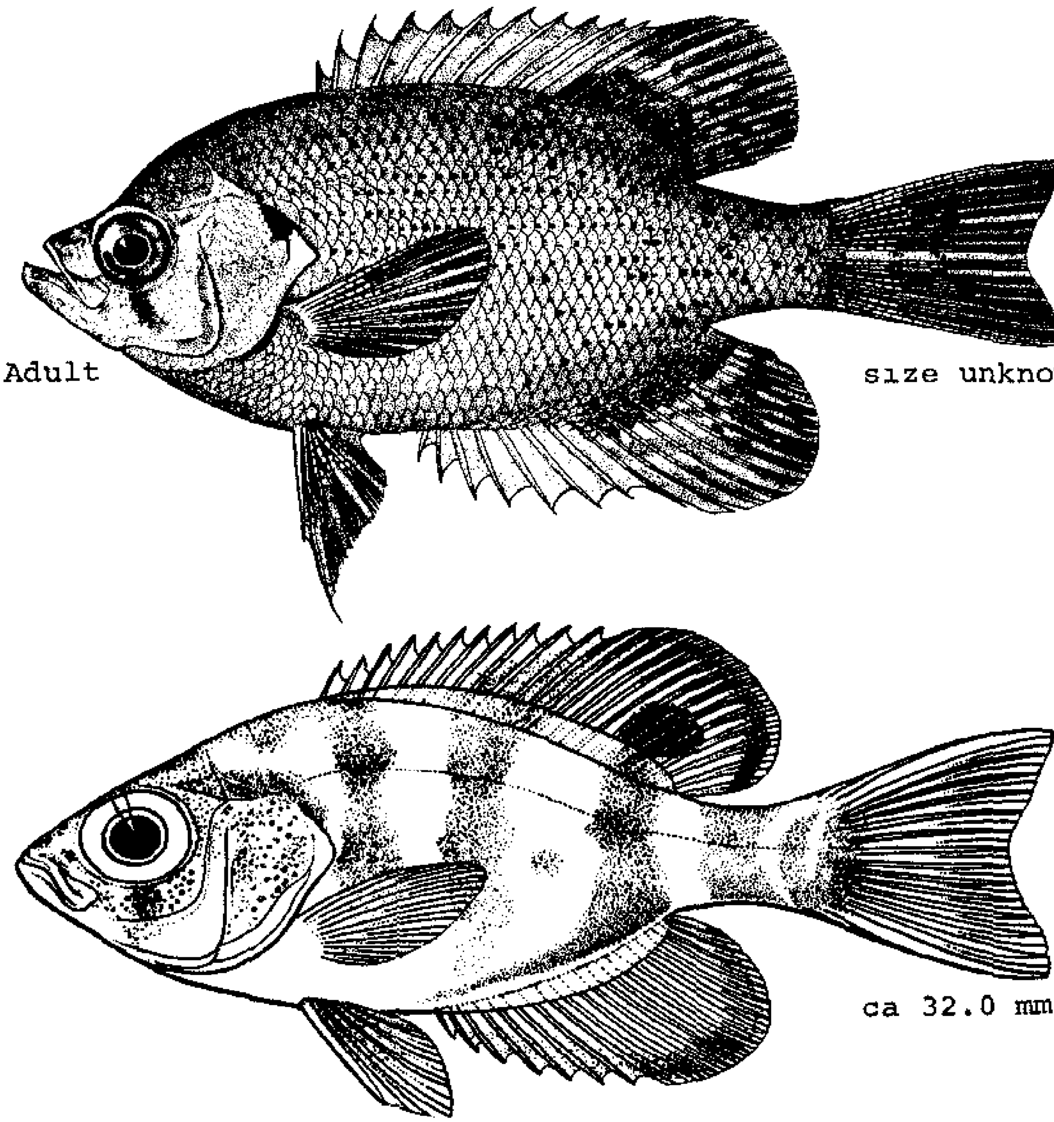
D. XI to XIII, 12–14;[5] A. VI[14] to VIII, 13–15; scales in lateral line 38–45,[5] in transverse series 21, above lateral line 6–7, on cheek 4[10]–7; gill rakers on lower branch 30, upper branch 10.

Depth 1.9–2.1 times in length;[14] eye 3.3[10]–4.0 times in head.[10]

Body short, deep, strongly compressed;[5] margin of opercle finely serrate;[8] gape extended to pupil[10] or middle of orbit;[14] lateral line complete;[5] dorsal and anal fins very high,[6] about equal.[5]

Pigmentation: Upper sides dark olive brown; flanks pale olive, bluish silver by reflected light; venter yellowish to white; several dark longitudinal bands on flanks, and a dark vertical band through eye. Dorsal, anal, and caudal fins transparent yellowish to reddish with orange, red, and black spots; dorsal fin with prominent ocellus posteriorly[5] (although this is presumably more developed in juveniles[14]); dorsal fin bordered with white in females,

A Adult



size unknown

B

ca 32.0 mm

Fig. 98. *Centrarchus macropterus*, Flier. A. Adult, size unknown. B. Juvenile, ca. 32.0 mm TL. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 417. B, Fowler, H. W., 1935: fig. 52.*)

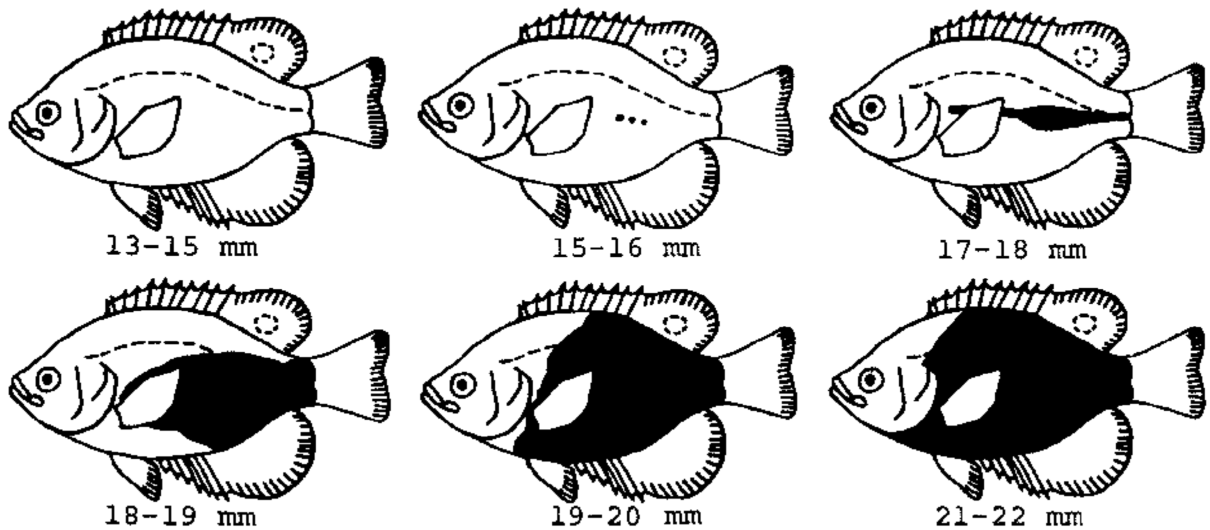


Fig. 99. *Centrarchus macropterus*, Flier. Scale development through a size range of 13–22 mm TL. (*Conley, J. M., and A. Witt, Jr., 1966: fig. 1.*)

black in males.[5] Pigment also described as greenish with each scale having a brown spot giving the appearance of rows of dots.[7,14]

Maximum length: 180 mm.[5]

DISTRIBUTION AND ECOLOGY

Range: Virginia southward along the coastal plain to Texas, north in Mississippi Valley to Illinois and Indiana.[6,7]

Area distribution: North in Chesapeake Bay drainage to York River, Virginia.[1]

Habitat and movements: Adults—sluggish or stagnant backwaters, overflow ponds, swamps[4] and sluggish streams[1] over bottoms of muck, sand and muck, rock and muck, sand, sand and clay, gravel and sand, and organic debris.[11] Maximum salinity, 7.0 ppt.[1] Temperature range 8–25 C.[16]

Larvae—no information.

Juveniles—a 64 mm specimen in upper part of a river with sand bottom and moderate current.[9]

SPAWNING

Undescribed, although spawning has been observed in aquaria.[2]

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Minimum size described, 15.0 mm.

Scales first evident at 15–16 mm (mean 15.8) mid-laterally along horizontal skeletogenous septum directly below union of dorsal fins; scales develop in single row anteriorly and posteriorly, but most rapidly toward tail; at 21 mm nape still scaleless; scale formation complete at 30–33 mm, average 31 mm.[3]

Pigmentation: In young a large, very prominent, black orange-bordered ocellus near posterior end of soft dorsal.[5,12] At about 32 mm 3 faint lateral bands on body extending well below lateral line and two similar bands on caudal peduncle; chromatophores over head, on opercle, and beneath eye; minute chromatophores basally in spinous dorsal and pelvic fins; soft dorsal and anal fins edged with band of chromatophores; dorsal fin with prominent ocellus.[13] In juveniles which appear to range in length from 37–50 mm, 3 or 4 major lateral bands, numerous widely spaced dark spots on ventral aspects of body, dorsal and anal fins with posterior pattern of alternating light and dark bands in addition to prominent ocellus.[5]

AGE AND SIZE AT MATURITY

Age at maturity, 2 years;[15] minimum known size at maturity, 80 mm.[5]

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Enneacanthus chaetodon (Baird), Blackbanded sunfish

ADULTS

D. IX to XI,[3] 10–13;[5] A. III, 10–13; P. 8–11;[3] V. I,[14] 4–5; scales in lateral line 23–30, above lateral line 4–6, below lateral line 9–12;[3] gill rakers 2[14] + 10–11.[9,12]

Proportions as times in SL: Head length 2.6–2.9, pectoral fin 3.2–4.2, caudal fin length 2.7–3.5. Highest dorsal spine 1.9–2.7 times in predorsal distance; shortest anal spine 1.7–3.0 times in highest anal spine; orbit 2.5–3.4, upper jaw 2.35–4.1 times in HL.[3] Greatest depth 1.7–2.0 times in TL; head 0.33 percent TL; eye 0.33 percent HL.[9]

Body short, deep, strongly compressed;[5] mouth very small, gape not reaching eye.[12] Teeth on vomer and palatines. Caudal fin round.[9]

Pigmentation: Grayish brown to black above;[11] sides dirty white, pale straw color,[9] gray-yellow, or greenish yellow, with pearly sheen[5] or, sometimes, blushed with pink or rose;[14] six to eight dark brown to black vertical bands on sides, the first running through the eye, those immediately behind the shoulder extending onto dorsal fin;[11] spaces between lateral bands irregularly blotched with gray or brown;[5] venter whitish.[11] Opercle and posterior edge of orbit with brilliant golden reflections. Eye orange anteriorly, white posteriorly,[9] and rimmed with gold;[11] also described as brownish.[14] Dorsal, anal, and caudal fins with up to 5 transverse rows of dark brown spots;[9] anterior rays of dorsal and pelvic fins sometimes orange;[5] pectoral fins colorless[9] or with blotch of orange red.[11] Spawning females more brilliant than males; spawning males pale dirty yellow, transparent, and with a prominent black opercular spot.[2,6,8]

Maximum length: 100 mm.[5]

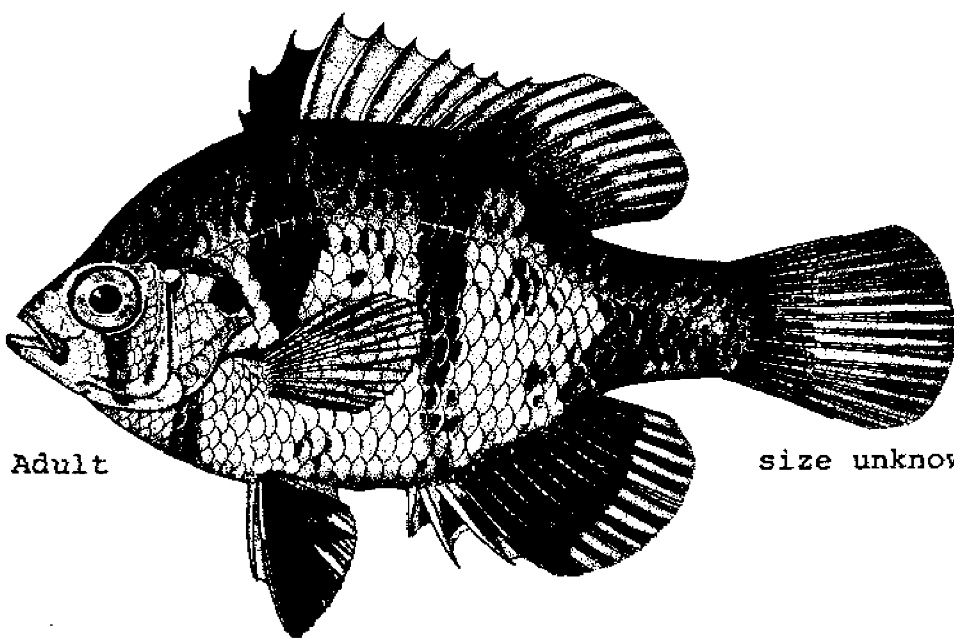
DISTRIBUTION AND ECOLOGY

Range: Coastal areas between Raritan River, New Jersey and St. Johns River, Florida; also Gulf coast drainages in Georgia;[6,17] introduced into Germany.[16]

Area distribution: Chowan River system, Virginia;[17] eastern shore of Maryland;[1] Delaware;[19] and New Jersey.[18]

Habitat and movements: Adults—confined to quiet, shallow, heavily vegetated, nonturbid, darkly stained, acidic water[17] (pH 4.0–5.0[2]) in swamps,[8,10] sphagnum bogs,[14] impoundments,[1] weed-grown holes in meadows,[4] ponds,[8,11] lakes,[11] rice ditches,[4] creeks,[9] slow flowing streams, and mouths of rivers[11] over bottoms of sand and muck.[13] Minimum recorded temperature, 5.5 C.[15]

Larvae—newly hatched stand on their tails on bottom.[8] Larvae swim to surface and sink back head first;[15] re-



A Adult size unknown

Fig. 100. *Enneacanthus chaetodon,* Blackbanded sunfish. A. Adult, size unknown. *(A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 423.)*

ported to hang on glass and plants (in aquaria) for 5 days before beginning to swim;[21] also attach to plants and stones after leaving nest.[16]

Juveniles—young along shore.[10]

SPAWNING

Location: In water 230[21]–305 mm deep among aquatic vegetation over bottoms of sand,[2] gravel[10] or small stones.[16] Nest variously described: 150 mm off bottom in a mass of vegetation;[2] over holes scooped out in sand, but in nest of aquatic vegetation having an entrance hole (so that the scooped hole becomes the floor of the nest);[20] in holes under vegetation[16,21] (but presumably, without the vegetation being modified into a nest, JDH). Diameter of nest depression ca. 80[15]–100 mm,[2] depth up to 20–30 mm.[15] Nest sometimes groove-shaped.[11] Bade commented that once the eggs are deposited they are covered with sand by the male.[15]

Season: In North Carolina occurs in March;[9] in Maryland eggs begin ripening in November;[3] in aquarium observations mid-April and end of June.[15]

Temperature: In aquaria specifically at 18.9 C;[21] also reported over range of 15–25 C.[11]

EGGS

Location: Attached to sand grains, forming clumps;[3] also attached to gravel.[10]

Ovarian eggs: Average diameter 0.3 mm in November in Maryland.[3]

Fertilized eggs: Sand-colored.[16]

EGG DEVELOPMENT

Incubation period at unspecified temperatures variously stated as 48 hours,[2,8] 3–6 days,[16] 4 days,[21] and 3–7 days[11] (some of these comments, however, may be based on time when larvae are first visible in nest, JDH).

YOLK-SAC LARVAE

Undescribed, except for comment that hatching length is 3.2 mm.[16]

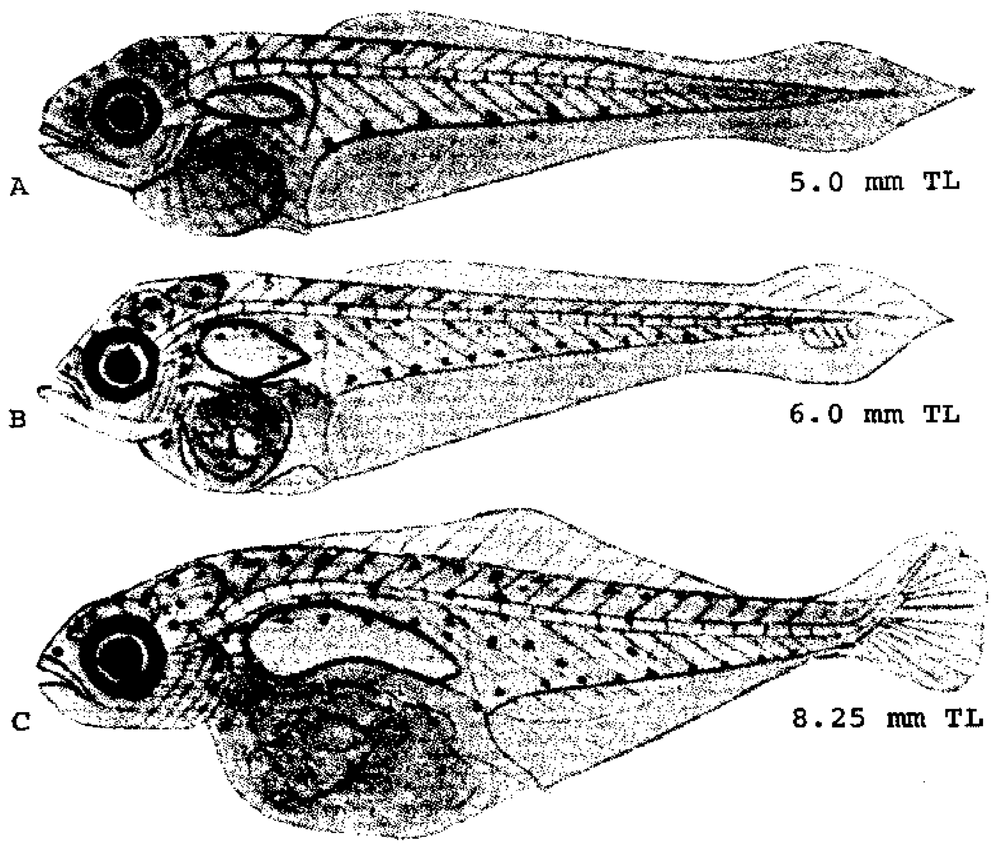


Fig. 101. *Enneacanthus chaetodon*, Blackbanded sunfish. A. Larva, 5.0 mm TL. B. Larva, 6.0 mm TL. C. Larva, 8.25 mm TL, urostyle flexed. (*A-C, Meinken, H., (not dated)a.*)

A

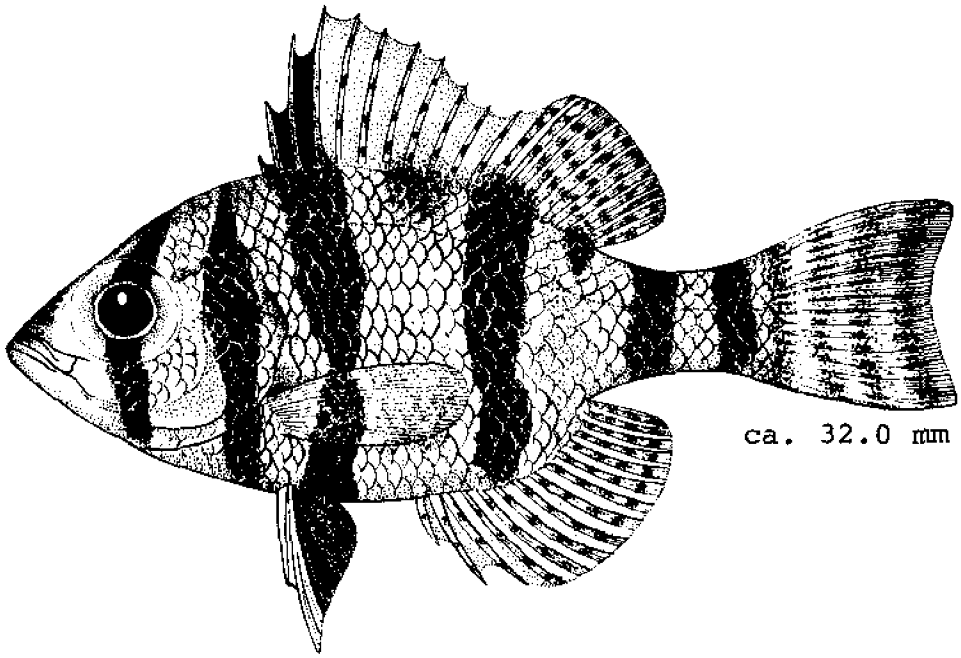


Fig. 102. *Enneacanthus chaetodon,* Blackbanded sunfish. A. Presumed juvenile (although length at maturity unknown), ca. 32.0 mm. (*A, Fowler, H. W., 1945: fig. 192.*)

LARVAE

Size range described, 5.0–8.25 mm.

Incipient rays in caudal fin at 6.0 mm, in dorsal fin at 8.25 mm. Urostyle oblique at 8.25 mm.[16]

Pigmentation: At 5.0 mm a series of 7 widely spaced large chromatophores ventrally between anus and tail, pigment on head and in a series of spots halfway back along dorsum. At 6.0 mm pigment on head and forward part of body increased, ventral chromatophores smaller, more numerous. At 8.25 mm widely scattered chromatophores over entire body.[16] Recently hatched larvae reddish yellow.[15]

JUVENILES

Minimum size described, 12.5 mm.

At 12.5 mm adult-like.[8]

Pigmentation: Young soft red, pectoral fins deep black.[11]

AGE AND SIZE AT MATURITY

No information.

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Enneacanthus gloriosus (Holbrook), Bluespotted sunfish

ADULTS

D. VII to XI, 9–13; [21] A. III to IV,[1,7,10] 8–13; P. 9–13; [21] V. I, 5; [15] scales in lateral line 25–35, rows above lateral line 4–7, rows below lateral line 10–13; [21] scales in transverse series 12–14; [12] scales around caudal peduncle 14–20, on upper caudal peduncle 6–9, on lower caudal peduncle 6–10; total gill rakers 8–15, upper 0–3, lower 8–13; [21] branchiostegals 6; [15] vertebrae 27–29, precaudal vertebrae 12; pyloric caeca 4–7.[21]

Proportions as times in TL: Head 2.75–3.05; depth 2.0–2.65.[10] Proportions as percent SL: greatest depth 37–59; caudal peduncle depth 13–20; head length 33–42; predorsal length 39–53; anal fin base 22–34; interorbital width 7–11; bony orbit 10–17.[21]

Body moderately deep, compressed; [10] males somewhat deeper bodied than females.[1] Mouth small, oblique, terminal or superior; maxillary to anterior margin of pupil. Lateral line lacking on several posterior scales. Caudal fin rounded.[10]

Pigmentation: Males dark green above; [10] sides pale olive, deep midnight blue,[13] or muddy brown; [19] each scale with a bright greenish,[1] azure, or blue-green [19] iridescent spot, these tending to form longitudinal stripes; [1,8] gut region semitranslucent; [1] a small black [7] or pearly blue [12] opercular spot, conspicuously smaller than pupil; [8] eye stripe indistinct.[7] Soft dorsal, anal, and caudal fins pinkish or reddish and with light blue spots; [1,10,19] spinous dorsal fin with or without blue spots; caudal fin with dusky margin; pectoral fins translucent, slightly greenish,[10] or olive; [10] pelvic fins plain,[10] or suffused with pink,[7] the longest ray reddish [10] or dusky. Iris wine-colored.[19] Females olive green [10] or pale olive, more drab than males [1] and with bluish spots sometimes lacking.[10]

Maximum length: 80.0 mm.[7]

DISTRIBUTION AND ECOLOGY

Range: Coastal areas from southeastern New York to Florida,[8] also from Jamesville, New York, in the Great Lakes drainage.[22]

Area distribution: Waters adjacent to Chesapeake Bay in Virginia and Maryland,[2] north to Havre de Grace, Maryland; [10] also Delaware,[20] and New Jersey.[19]

Habitat and movements: Adults—in shallow water of acid ponds,[2,17] and sluggish waters [10] of streams,[1,2,8] shallow creeks and canals,[5,6] and rivers [17] over bottoms of rock, sand, muck, and organic debris,[16] also once recorded in vegetation-free flood plain ponds over mud bottom; [11] usually in weedy areas [5] associated with aquatic vegetation [10] such as *Potomogeton* [1] and *Myriophyllum*.[6] Maximum recorded depth 900–1200 mm.

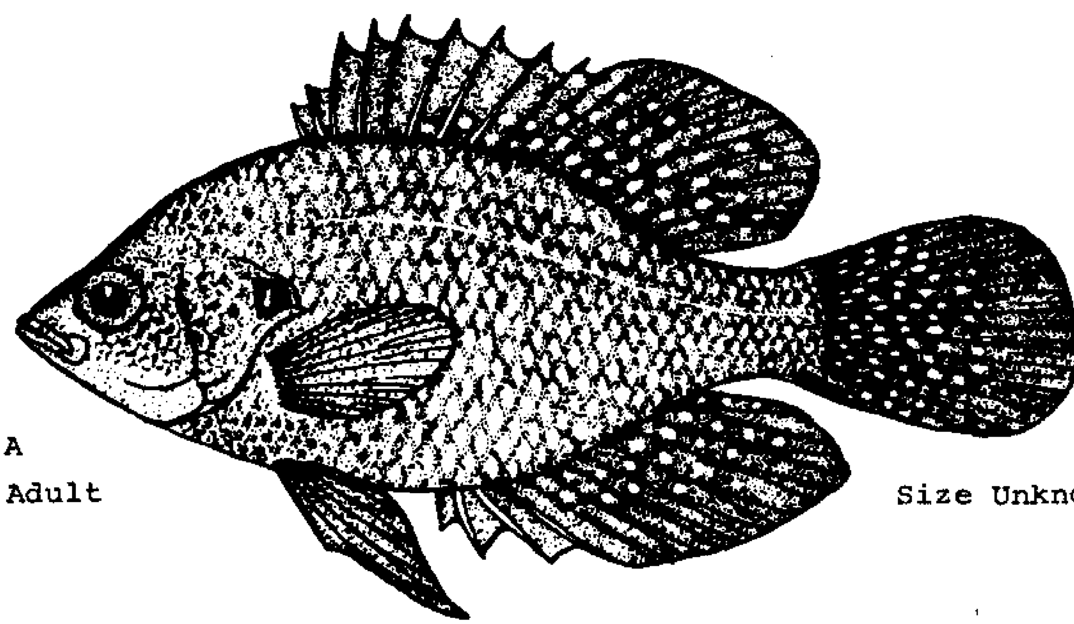

Fig. 103. *Enneacanthus gloriosus*, Bluespotted sunfish. A. Adult, size unknown. (*A, Eddy, S., 1957: fig. 465.*)

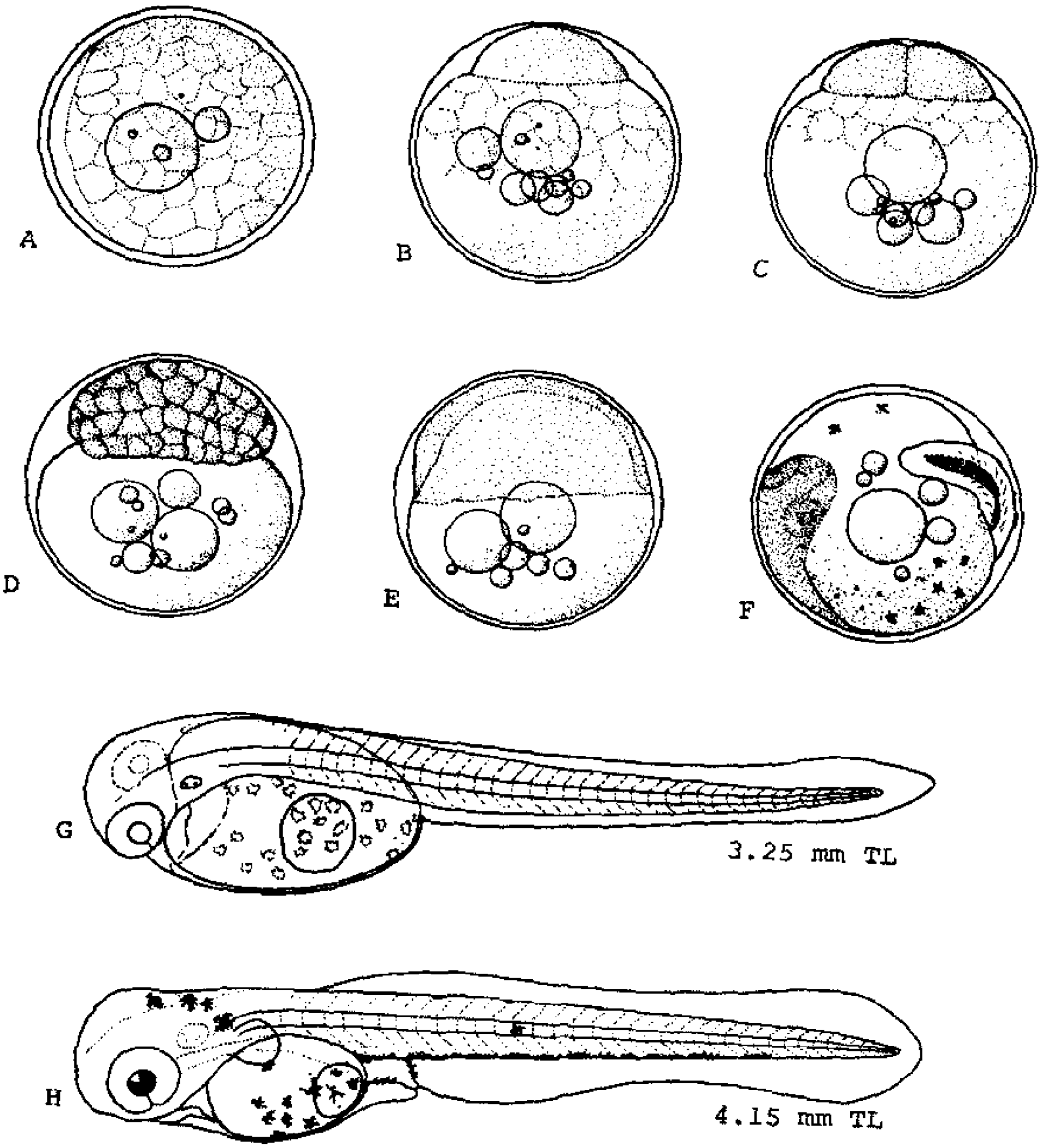

Fig. 104. *Enneacanthus gloriosus*, Bluespotted sunfish. A. Unfertilized egg. B. Blastodisc just formed. C. 2-cell stage. D. Morula. E. Early embryo, blastoderm to equator of egg. F. Pre-hatching stage. G. Newly hatched larva, 3.25 mm. H. Yolk-sac larva, 4.15 mm TL. (*A-H, Breder, C. M., Jr., and A. C. Redmond, 1929: figs. 327–328.*)

...imum salinity 12.88 ppt [10] (although experimentally ...ived for several days at 21.5 ppt [21]). Recorded ...perature range 17–31 C.[5]

...ac—swim to surface and hang suspended from ...ace film.[1]

...iles—no information.

SPAWNING

Location: In shallow water (maximum recorded depth, 305 mm) in moss,[4,23] among fine-leaved plants,[14] in filamentous algae or among rootlets.[4,23]

Season: Occurs from March (based on spawning colors)[5] to September[1] throughout range, although there are apparently two periods of ripeness, one in spring and one in late fall;[14] in Florida, March and April,[5] and again in August and September;[11] in Potomac River, May and June;[3] in New Jersey, June 15[23] to early September.[1]

Temperature: Probably occurs at about 20 C.[3]

EGGS

Location: Demersal,[1] attached to rootlets.[4]

Fertilized eggs: Spherical, diameter ca. 0.9 mm; egg membrane "fairly adhesive"; yolk very pale amber; 2–16 (average 7) lemon yellow, highly refractile oil globules of various sizes; largest oil globule 0.325 mm.[1]

EGG DEVELOPMENT

Development at 22.7 C:[1]

20 minutes.	water-hardened, blastodisc formed.
35 minutes.	a distinct groove evident around edge of blastodisc.
45 minutes.	2-cell stage.
80 minutes.	4-cell stage.
100 minutes.	8-cell stage.
3 hours, 30 minutes.	egg somewhat oval.
8 hours.	germ ring visible and with evidence of anterior-posterior differentiation.
11 hours, 30 minutes.	blastopore closed.

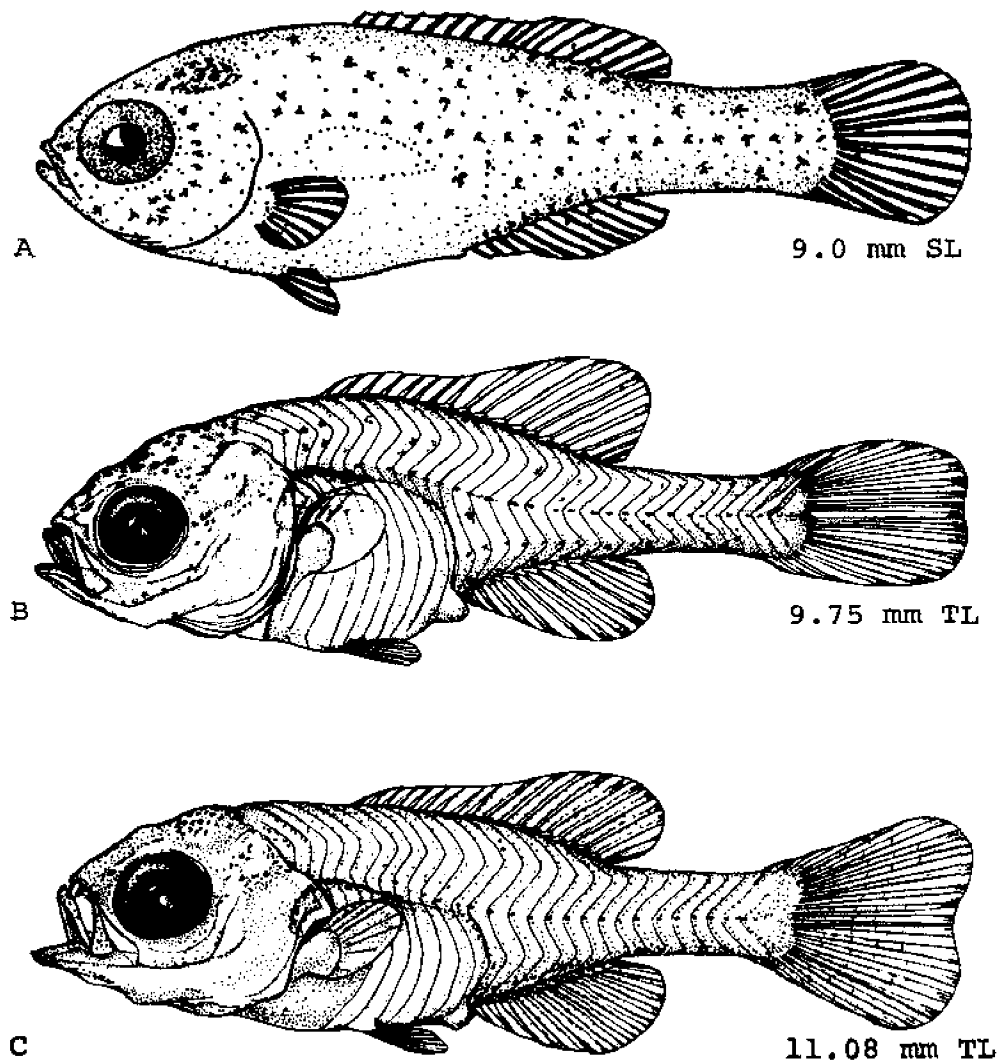

Fig. 105. *Enneacanthus gloriosus*, Bluespotted sunfish. A. Larva, 9.0 mm SL (but apparently less advanced than following stage). B. Larva, 9.75 mm TL. C. Larva, 11.08 mm TL. (*A, Breder, C. M., Jr., and A. C. Redmond, 1929: fig. 328C. B, C, Anjard, C. A., 1974: 182.*)

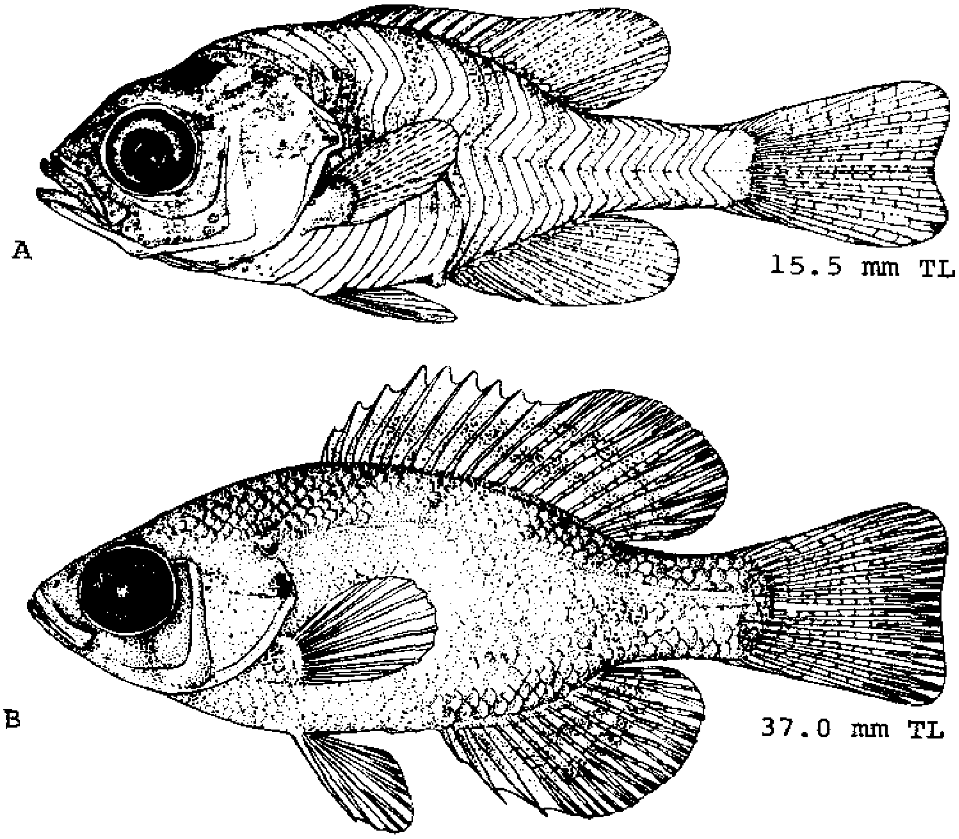

Fig. 106. *Enneacanthus gloriosus*, Bluespotted sunfish. A. Juvenile, 15.5 mm TL. B. Juvenile, 37.0 mm TL. (A, Anjard, C. A., 1974: fig. 183. B, Original illustration, A. J. Lippson.)

21 hours. segmentation evident.
45 hours. heartbeat, movement established; some melanophores evident on yolk.
57 hours. hatching.

Incubation period: At 22.7 C, 57 hours,[1] at an unspecified temperature, 3 days.[14]

YOLK-SAC LARVAE

Average hatching length, 2.3 mm (although newly hatched illustrated, 3.25 mm); length at end of stage 6.0–7.0 mm.[3]

Myomeres 13–14+14–17.[3] Head sharply deflected over yolk at hatching (3.25 mm), straightened at 4.15 mm. Oil globules consolidated shortly after hatching to form single oil globule. Yolk still evident but reduced, mouth open at 36 hours. Two otoliths evident at hatching (3.25), 3 at 4.15 mm. Pectoral fins first evident at 40 hours; at 4.15 mm rounded, rayless.[1]

Pigmentation: At hatching some pigment on yolk, eyes unpigmented. At 30 hours scattered chromatophores on yolk and over brain; ventral artery heavily pigmented. At 4.15 mm a band of pigment ventrally beyond anus, chromatophores also above and below gut near anus, on yolk sac, and on head; single prominent chromatophore on midline of body one-fourth way between anus and tip of tail and several small chromatophores dorsally between anus and tip of tail.[1] Eye pigment in some specimens at 4.0 mm,[3] not in others at 4.15 mm.[1]

LARVAE

Size range described 6.0–11.08 mm.[3]

Opercular flap well differentiated at 9.75 mm, choroid fissure still vaguely evident. At 9.75–11.08 mm, depth 3.33–3.80 times in TL. Urostyle flexed and extended into caudal fin at 9.75 mm.[3] Dorsal fin spines and rays countable at 8.2 mm;[1] pelvic fins well formed at 9.75 mm; pectoral fins without rays at 11.08 mm, and apparently last fin to form rays; at 11.08 mm neither pectoral nor pelvic fins extended posteriorly to level of anus; emarginate caudal at 11.08 and later stages[3] is questioned (JDH).

Pigmentation: In living or freshly killed specimens a marked iridescence. At 9.75 mm numerous large stellate chromatophores on top of head, and few scattered chromatophores on upper sides of body; an indefinite row of chromatophores ventrally between anus and tail, and a heavy row of dark spots in region of future lateral line; some pigment on cheeks and opercle. At 11.08 mm body pigment more or less as in previous stage, additional pigment on lips, sides of head, and breast; opercular spot indicated by dense concentration of pigment cells; pigment developed in dorsal, anal, and caudal fins.[3]

JUVENILES

Minimum size described, 15.5 mm[3] (the statement that a 10.5 mm specimen is fundamentally similar to adult[1] is questioned, JDH).

At 15.5 mm snout short, caudal peduncle long. Depth about 3.1 times in TL. Pectoral and pelvic fins extended to or slightly beyond level of anus.[3]

Pigmentation: At 15.5 mm ca. 8 indistinct vertical pigment bars developed on body and pigment evident along longest rays of pelvic fin, opercular spot not evident.[3] At about 25 mm, 6 narrow pigment bars, 2 of which appear to extend to venter; pigment on snout and beneath eye well defined; opercular spot well-developed; body with numerous large diffuse spots.[18] Lateral bars still evident at about 45 mm, but fading. Young described as dusky *olive usually with 7 broad black bars on sides and with* poorly developed spotted pattern; when disturbed, capable of color changes, thus varying, when viewed from above, from dull sand color to steel blue.[1]

AGE AND SIZE AT MATURITY

No information.

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Enneacanthus obesus (Girard), Banded sunfish

ADULTS

D. VII to XI, 9–12; A. III to IV,[13] 8[2]–14; P. 10–13;[13] V. I, 5;[7] C. 17;[11] scales in lateral line 27–35,[13] above lateral line 3[2]–6,[13] below lateral line 9[2]–13, on caudal peduncle 17–24, on lower caudal peduncle 8–12, on upper caudal peduncle 7–10,[13] on cheek 4;[8] total gill rakers first arch 10–15, on upper limb 1–4, lower limb 9–13;[13] branchiostegals 6;[7] pyloric caeca 4–9; precaudal vertebrae 12; total vertebrae 27–29.[13]

Proportions as percent SL through size range of 20–75 mm (thus including some juveniles): Pectoral fin length, 24–34; pelvic fin length, 20–36; dorsal fin base, 37–54; anal fin base 20–33; interorbital width, 7–10; head length 32–42; eye diameter, 10–16; predorsal length, 40–52; depth of caudal peduncle, 13–20; greatest depth, 40–56.[13]

Body relatively short,[2] elliptical,[6] deep, strongly compressed;[2] gape extended to center of pupil; nares usually round, occasionally oval; dorsal edge of operculum straight. Lateral line usually incomplete.[13] Dorsal fin larger than anal fin, inserted on level with base of pelvic fins;[2] caudal fin rounded.[6]

Pigmentation: Olive brown,[2] olive green,[13] or fawn, the upper sides darker;[3] sides with 5–8 irregular transverse dark bars,[2] each 3–4 scales wide,[13] and numerous green,[2] purplish, golden,[3] brass-colored,[2] or blue spots;[3] venter pale yellow to white;[2] gold spots and lines on cheeks,[13] and a dark stripe under eye;[2] opercular spot velvety black,[6] edged with purple[6] or gold,[2] more than one-half diameter of eye;[13] eye yellowish brown; vertical fins fawn, often with strong red tinge and iridescent green spots;[2] spinous dorsal fin with light blue spots.[3] Breeding males with bright blue-green and gold spots on sides, blue spots on dorsal, anal, and pectoral fins.[12]

Maximum length: 100 mm.[2]

DISTRIBUTION AND ECOLOGY

Range: Southern New Hampshire to central and extreme western Florida, predominantly on the Atlantic Coastal Plain, but extending north of the Fall Line in New England.[13] Introduced into Germany, but now extinct there.[2]

Area distribution: Coastal areas of Maryland, Virginia,[1] Delaware,[13] and New Jersey.[15]

Habitat and movements: Adults—sluggish streams, acid water swamps,[1] shallow coves,[5] ditches,[1] and ponds,[13] over bottoms of mud,[1,5] sand, muck, and organic debris;[9] typically associated with vegetation;[4,5,6,10,12] sometimes in stagnant water.[9] Maximum recorded salinity in nature, 3.33 ppt;[16] but under experimental conditions, some survival up to 21.5 ppt, 100% survival up to 17.0 ppt.[13]

Larvae—no information.

Juveniles—no information.

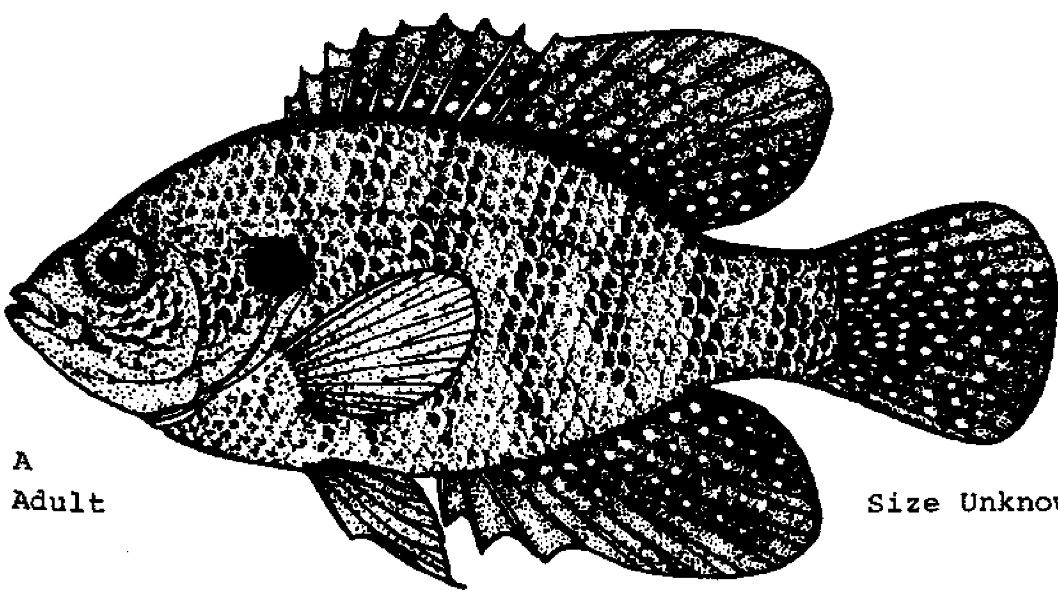

Fig. 107. ***Enneacanthus obesus***, Banded sunfish. A. Adult, size unknown. *(A, Eddy, S., 1957: fig. 464.)*

SPAWNING

Location: In nest, exact location unspecified.[12]

Season: Under experimental conditions occurred in November (15 hours of light at 21.7 C).[12]

EGGS

Largest ovarian eggs 0.50–0.74 mm.[12]

EGG DEVELOPMENT

Incubation period 3 days, presumably at 21.7 C.[12]

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Size range described, 20[13]–36 mm.[11]

Proportions as percent SL at 20–30 mm: Length of dorsal fin base 37–49, diameter of bony orbit 13–16, greatest depth 40–51.[13]

Pigmentation: In a specimen 36 mm long lateral bands, subocular bar well defined; vertical fins heavily mottled.[11]

AGE AND SIZE AT MATURITY

Minimum size at maturity, males 45 mm.[12]

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Lepomis auritus (Linnaeus), Redbreast sunfish

ADULTS

D. X to XI,[10] 10–12,[17] mean number of spines 10.19, mean number of rays 10.89;[6] A. II[13] to IV,[27] 8[10]–11,[13] mean number of rays 9.19;[6] V. I, 5;[21] P. 13–14[27] (although mean number stated as 14.04);[6] scales in lateral line 41[13]–48[27] (mean number 44.26[6]); above lateral line 6[17]–9[13] (although mean 6.93[6]), below lateral line 13[17]–16[13] (mean number 14.19[6]); on cheek 5–6,[17] on caudal base ca. 4;[23] gill rakers on lower limb of first arch 8–9[17,22] (but mean number stated as 9.04[6]), on upper limb 5; branchiostegals 5–7;[27] vertebrae 13+16–17=29–30;[21] pyloric caeca 7.[27]

Proportions as percent TL: Depth at dorsal fin origin 32.2–39.9, depth of caudal peduncle 12–14, head 28.2–30.3, dorsal fin base 43.4–49.4. Length of dorsal fin base 2.5 times length of anal fin base.[27]

Body strongly compressed;[10] mouth terminal, somewhat oblique, gape not reaching anterior margin of eye. Opercular margin deeply fimbriate. Teeth present on palatines and jaws.[27] Gill rakers short,[11] stiff.[12]

Pigmentation: Brownish olive or brownish violet above; sides gray-green above, greenish yellow below[10] or golden brown to olive,[27] with vertical bars of varying intensity[14] and, sometimes, reddish and bluish streaks;[12] scales on sides pale bluish with reddish centers;[17] venter yellowish white,[13] yellow,[18] or bright orange-red; head with pale blue lines and spots; flap of gill cover deep black,[10] but with pale lower margin;[17] vertical fins light yellow,[18] dirty yellow, brownish,[10] or orange,[17] sometimes mottled with darker; leading edge and tip of pectoral fin dark;[27] no black spot on posterior dorsal fin rays.[11] Old individuals predominantly brown.[10] Spawning females considerably darker than males; vertical bars in females prominent, in males obscure.[14]

Maximum length: About 305 mm.[13]

DISTRIBUTION AND ECOLOGY

Range: New Brunswick, Canada, south, east of the Appalachians, to central Florida; west on the Florida panhandle to Apalachicola River; introduced in Texas, Oklahoma,[11,27] and Puerto Rico.[7]

Area distribution: Tributaries of Chesapeake Bay;[3,22] also Delaware[16,27] and New Jersey.[28]

Habitat and movements: Adults—typically a solitary species, although sometimes forming small groups. Usually found inshore[2] in rivers, streams,[13] creeks, sloughs,[15] lakes, and ponds[13,31] over bottoms of rock, gravel,[14] sand,[15] sand and gravel, organic debris,[16] or mud;[27] frequently associated with aquatic vegetation.[15,16] Maximum recorded salinity, 0.98 ppt.[29] Form closely compacted aggregation at temperatures of 5 C or below[2] if

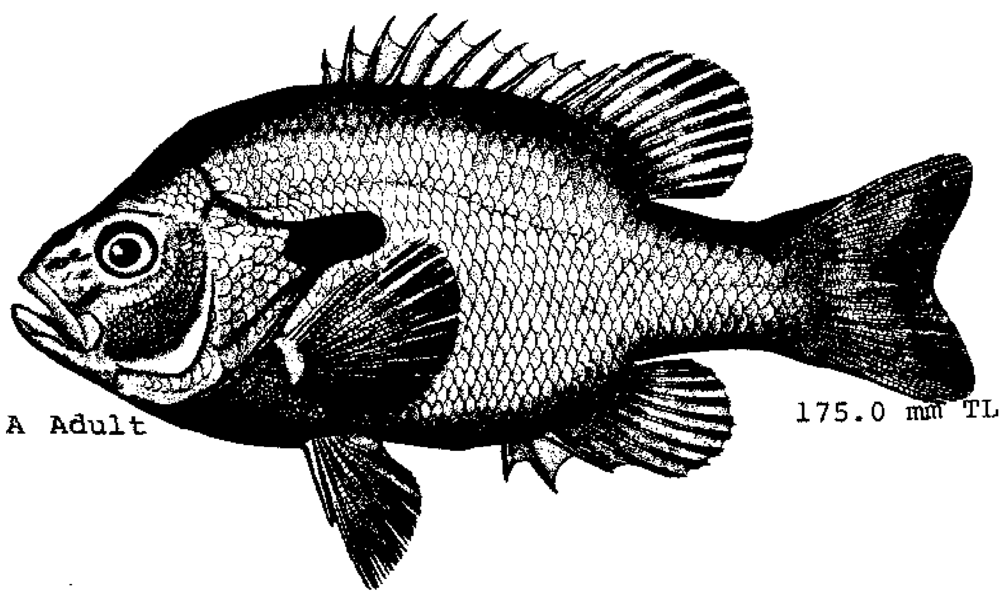


Fig. 108. *Lepomis auritus*, Redbreast sunfish. A. Adult, 175.0 mm TL. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 425.*)

there is slight current or abnormally high CO_2 concentration.[20] Move inshore in spring when water temperatures have reached 10 C, with males arriving inshore before females.[27]

Larvae—no information.

Juveniles—"young" remain in small schools after leaving nest [2] and throughout first summer; [14] typically associated with aquatic vegetation [15] and recorded over bottoms of mud and rock.[14]

SPAWNING

Location: In ponds, lakes,[2] streams,[4] canals,[31] and rivers [7] over bottoms of sand [5] or gravel [9,26] at depths of 150 [4]–1140 mm [31] (although in tidal water depth above the nest may vary from 0–1525 mm); [5] in one series of observations where depth varied from 480–760 mm, the average depth was 685 mm.[9] Sometimes attempt to spawn over mud, but such spawnings are unsuccessful.[4] Typically among plants, near submerged logs, stumps, and snags,[31] near shore lines with overhanging banks,[18] or downstream from a protective rock.[27] In rivers tend to spawn in faster flowing water than most sunfishes.[9] In ponds and lakes, nest close together; in streams, usually solitary.[14,18,27] Nests are evenly scooped out circular depressions with gravel bottoms.[9,18,26,31] Nest diameter 255–1015 mm; [4] depth typically 50 mm,[18] but 102–127 mm in nest exposed by low tide.[5] Sometimes spawn in nests of other species.[27]

Season: In Puerto Rico, year round; [7] in Florida, ripe ova April through October,[31] reproductive activity April [15] through August; [31] in Georgia ripe females in April,[34] nest construction in June, some spawning by June 9, few gravid females and no nest after July; [33] in Virginia, July; [5,8] in New Jersey, presumably May to August; [1] in New York June 6 to August 12 with peak mid- to late June; [4,27] in Connecticut June 1 to mid-August; [14] in Maine, begin in June.[26]

Time: Spawning observed at 1100 hours and 1500 hours.[9]

Temperature: Nest building begins at 16 [2]–21.1 C; [26,30] nest building and, presumably, spawning observed at 27.8 C.[4,27]

Salinity: Once reported to spawn in a river where water was perceptibly brackish during dry weather.[5]

Fecundity: 322 [33]–9968; [30] fecundity increases with age, thus between age groups II and VI average number of eggs increased from 963 to 8250; [32] in stripping experiments, 20–60 mature eggs.[6]

EGGS

Location: Deposited in nest; [19] attached to gravel and to each other, sometimes forming large clumps.[14]

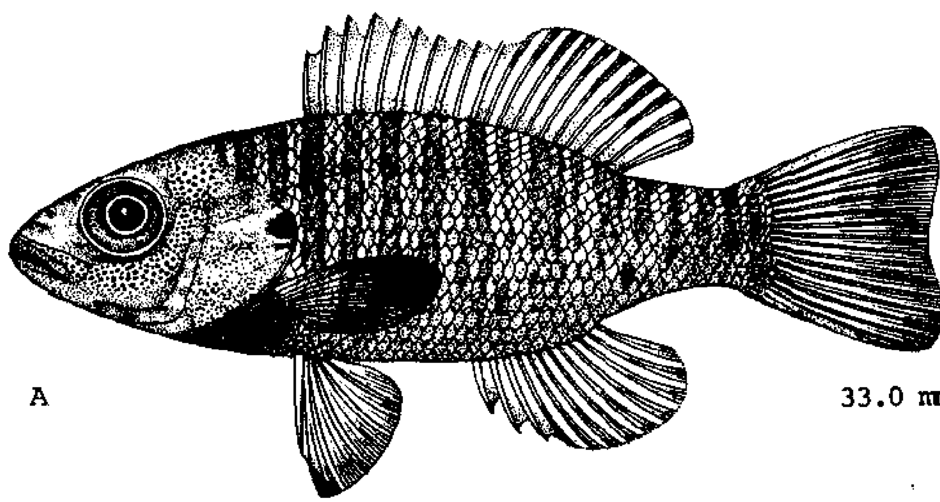
Ripe ovarian eggs: Diameter 0.90–1.64 mm (average 1.20 mm).[33]

Fertilized eggs: Bright yellow [1] or amber,[27] nearly transparent; [19] average diameter 1.8 mm; chorion adhesive; yolk with a single large and several small oil globules; diameter of largest oil globule about 0.6 mm.[1]

EGG DEVELOPMENT

No information.

A



33.0 mm TL

Fig. 109. *Lepomis auritus*, Redbreast sunfish. A. Juvenile, 33.0 mm TL. (*A, Fowler, H. W., 1945: fig. 252.*)

YOLK-SAC LARVAE

No information.

LARVAE

Size range described, 7.0–10.0 mm.[35]

Gut with conspicuously developed coils at 7.0 mm.[35]

Pigmentation: At 7.0 mm melanophores on dorsal surface of brain case, a single row of melanophores along lateral line, and 20–30 minute melanophores ventrally between operculum and anus. At 10.0 mm scattered melanophores over entire body.[35]

JUVENILES

At 17 mm sides with faint ventral bars.[35] At about 33 mm opercular spot evident, about 15 narrow vertical lateral bars, each about as wide as the interspaces.[25] In young, bluish stripes on head not as distinct as in adults.[24]

AGE AND SIZE AT MATURITY

Age group II;[32] males ca. 100 mm, females ca. 75 mm.[14]

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Lepomis cyanellus Rafinesque, Green sunfish

ADULTS

D. IX[9] to XI, 10[11]–12;[9] A. III 8[11]–10;[9] P. 12–13;[22] V. I, 5;[20] scales in lateral line 40[22]–59,[14] above lateral line 6[11]–11,[14] below lateral line 15[11]–21,[14] on cheek 7–10;[9,29] gill rakers about 14 on lower branch of first arch, 5–6 on upper; branchiostegals 6–7; vertebrae 28–29; pyloric caeca 6–8.[22]

Proportions as times in TL: Greatest depth 30.3–34.1; depth of caudal peduncle 12.0–13.0; head 27.8–31.9. Eye 18.6–31.3 percent HL.[22]

Body oblong,[38] not as deep as in other sunfishes,[12] compressed;[11] caudal peduncle a little longer than deep; head depressed over eyes;[22] gape to middle of eye;[21] gill rakers long, straight, thin 1/4 to 1/2 eye diameter.[26,29]

Pigmentation: Dorsum olive green to olive slate;[5] sides olivaceous,[9,25] gray-green to vivid shiny green,[11,13] brown,[22] yellowish green,[3,5,21] or golden (in a Texas population);[27] also described as darkest above, yellowish or coppery below;[9,25] sometimes a series of 7–12 dark, vague, vertical bars,[3,22] but these often absent; each scale with a blue or green spot, and more or less edged with gold, thus giving appearance of pale lateral streaks.[9,25] Head with emerald spots or, sometimes, 3–5 narrow, wavy broken emerald lines;[22,26] top of head, premaxillaries, and preopercle dark bluish green; opercular spot dark blue to black;[9] opercular flap edged with yellow, pale red, pink,[22] purplish,[26] or coppery.[18] Eye red.[9,21] Venter white, yellow white, or pale yellow.[5,22] Older individuals uniform gray-green.[11] Dorsal and anal fins greenish yellow to olivaceous,[9] edged with white, yellow, or orange[22,25] and usually with a dusky spot or spots on last 3–5 rays;[9,26] caudal fin greenish yellow to olivaceous with whitish margin;[10] pectoral fins clear; pelvic fins clear, dusky, olive or yellow.[5,22,26]

Maximum length: 305 mm.[22]

DISTRIBUTION AND ECOLOGY

Range: Colorado and South Dakota through Minnesota, Wisconsin, and upper peninsula of Michigan to extreme southern Ontario and western New York; southward through lower Great Lakes and Mississippi basin to Georgia and southern Alabama, northeastern Mexico, and New Mexico; stated limits of range may have resulted, in part, from plantings.[15] Introduced in Nevada,[37] Utah, California,[22] and Maryland.[21]

Area distribution: Introduced in Potomac drainage near Washington.[4,21,32]

Habitat and movements: Adults—in small rivers; sluggish creeks;[15,26] slow moving muddy areas of low or moderate gradient streams,[5,14,32] or pools in streams; brooks;[5] canals;[32] oxbows;[5] ponds;[14,19] impoundments; and small lakes[7] (although apparently uncommon in lakes in some areas);[10] over bottoms of rock, gravel, sand, silt, mud, clay, marl; and sometimes, beds of *Ceratophyllum* or *Lemna*;[24] frequents brush piles. Appear to be more tolerant of turbidity than other sunfishes,[22] and generally tolerant of adverse environmental conditions.[14] Maximum salinity, 0.7 ppt.[23] Recorded temperature range 3.9[24]–28 C[22] (although experimentally able to tolerate 33.3–34.4 C for hours or days[36]). Maximum recorded depth 4.6 m.[24] Will home from distances of up to 670 m when displaced.[17,31]

Larvae—become free-swimming 210 hours after fertilization at 24 C,[34] or in minimum of 7 days at 27–28 C; also reported free-swimming at length of about 4.2 mm. Under laboratory conditions, prior to "swim-up," which occurs at 6.0–6.3 mm, attached to aquarium glass and artificial vegetation by dorsal surface of the head.[39]

SPAWNING

Location: Occurs near shore[9,18] in water 38[22]–1040 mm deep (in one study, average 430 mm[8]) over bulrushes[28] or near logs,[30] clumps of vegetation or rocks.[22,28] Recorded from a variety of bottom types: gravel,[9] cinder and gravel,[30] marl,[28] and, rarely, muck (although in muck digs down to expose underlying marl). Commonly nest in unshaded areas.[30] Hubbs[18] felt that this species was not a nest builder, but this has been questioned;[6] described as both a typical solitary nester in which only small aggregations are found,[8] and as a colonial spawner;[9,22] a single nest described as ca. 300 mm in diameter and 76 mm deep in black mud.[28]

Season: In Colorado spawning occurs from early June to mid-August;[9] in Wisconsin late May to early August;[30] in Michigan late June to August;[6] in Illinois late April or early May through first week of September with stunted populations 2 to 4 weeks later than nonstunted populations.[26] In Wisconsin, older fish begin spawning in May, 1 year olds in July or early August. Spawning is cyclic with nesting occurring at average frequency of every 8 or 9 days. Males generally remain on the nest for 4–9 days, but this may vary from 1–15 days.[30]

Time: Never spawns at night.[30]

Temperature: Spawning initiated at 15.6[36]–21 C,[26] and usually occurring on a rising temperature;[30] peak activity observed at temperature range of 20–28 C.[22]

Fecundity: Ca. 2000–10,000,[9] but in stripping experiments 68[6]–315.[26]

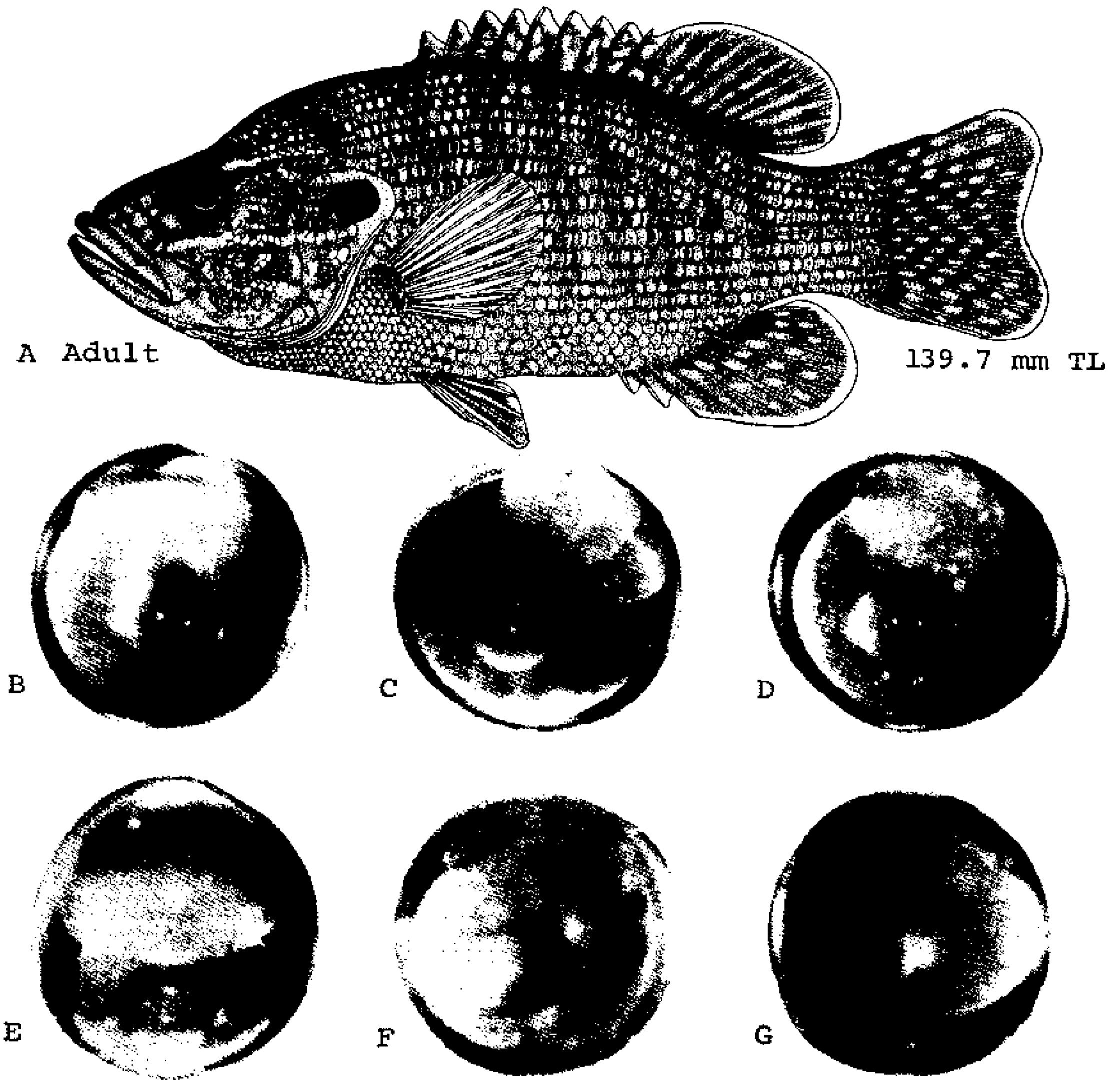

Fig. 110. *Lepomis cyanellus*, Green sunfish. A. Adult, 139.7 mm TL. B. 4-cell stage, 1 hour after fertilization. C. 8-cell stage, 2 hours. D. Morula, 5 hours. E. Gastrulation, 11 hours. F. 12 somites, brain segmented, 21 hours. G. Trunk movement established, eyes formed, 28 hours. (*A, Trautman, M. B., 1957: fig. 133. B-G, Champion, M. J., and G. S. Witt, 1976: fig. 1.*)

EGGS

Location: Attached to willow,[16] bulrush, and sedge roots,[28] sometimes at the very edge of the water.[18]

Fertilized eggs: Diameter 1.0–1.4 mm,[1] average diameter 1.23,[33] yellow, adhesive,[22] yolk with a single oil globule 0.45 mm in diameter.[83]

EGG DEVELOPMENT

Development at 24 C:[34]

2 hours	1- to 8-cell stages.
5 hours	morula.
7 hours	blastula flattened, blastocoel formed.
8 hours	blastoderm over 1/3 of yolk.
11 hours	blastoderm over 3/4 of yolk.
14 hours	embryonic shield visible, elevated.
15 hours	neural groove prominent, brain differentiating.
19 hours	somites forming.
21 hours	12 somites, brain clearly segmented.
25 hours	optic cups forming.
28 hours	lens formed, muscular contractions in

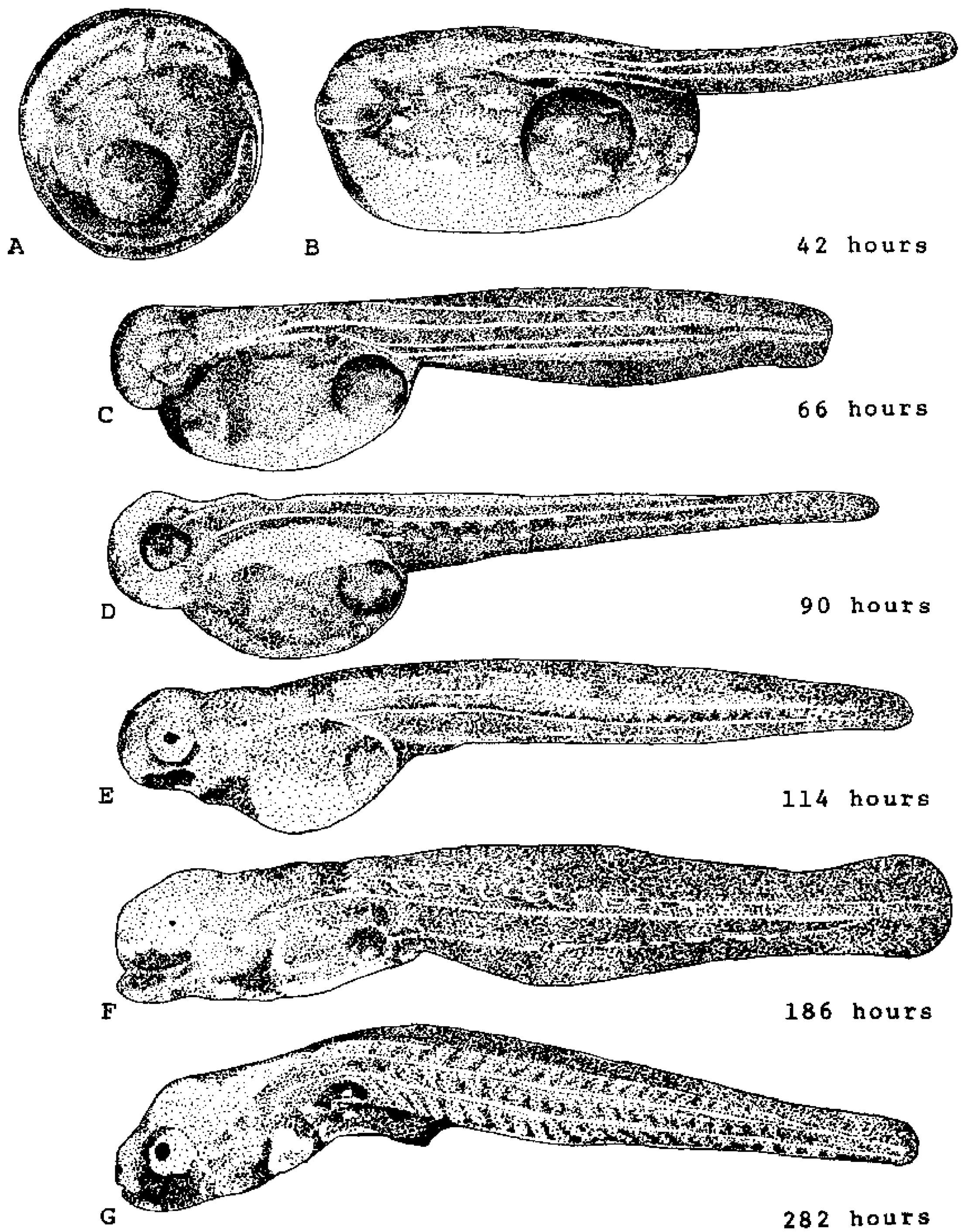

Fig. 111. *Lepomis cyanellus*, Green sunfish. A. Pre-hatching stage, 38 hours after fertilization. B. Yolk-sac larva, newly hatched, 42 hours after fertilization. C. Yolk-sac larva, eye faintly pigmented, 66 hours after fertilization. D. Yolk-sac larva, gas bladder formed, eyes darkly pigmented, 90 hours after fertilization. E. Yolk-sac larva, sustained swimming established, 114 hours after fertilization. F. Yolk-sac larva, yolk reduced, gills and jaws moveable, 186 hours after fertilization. G. Larva, pigment formed ventrally beyond anus, 282 hours after fertilization. (*A-G, Champion, M. J., and G. S. Witt, 1976: fig. 1, Tamiko Karr, delineator.*)

trunk.
31 hours heartbeat established.
38 hours pre-hatching stage, otoliths visible.[34]

Incubation period: At 21.1 C, ca. 3 days (but age at start unknown); [1] at 23.8 C (SD 0.27) means varied 49.2–50.8 hours, combined samples 50.0 hours (SD 2.37); [26] at 24 C, between 38 and 42 hours; [34] at 27.1 C (SD 0.44) means varied 30.7–32.8 hours, combined samples 31.5 hours (SD 2.08); at 27.6 C (SD 0.32) means varied 28.8–29.8 hours, combined samples 29.1 (SD 1.75).[26] Develop normally in water as warm as 28.3 C.[2]

YOLK-SAC LARVAE

Hatching length, 3.6–3.7 mm; maximum length, some yolk apparently retained to at least 6.0–6.3 mm; [39] age at end of stage (based at time from fertilization) 282 hours.[33]

Preanal myomeres 11, postanal myomeres 16–17, total myomeres 27–28.[39]

Yolk sac elongate, deep at hatching, greatly reduced at 186 hours. Oil globule in posterior half of yolk sac at hatching, at extreme posterior end of yolk at 54 hours, still evident at 186 hours.[33] Mouth grooved but not open at 70–90 hours.[39] Jaws movable at 126 hours, prominent mouth parts at 186 hours.[33] Gill buds present at 5.6–5.7 mm. Pectoral buds present at hatching.[39]

Gall bladder evident at 138 hours. Development of gas bladder variable described: in series reared at 24 C, first visible 78 hours after fertilization, inflated at 114 hours; [33] in another series first evident at 50 hours, with anlagen of pneumatic duct at 68–78 hours; [2] described as well-developed and full at 5.6–5.7 mm (129 hours).[39]

Pigmentation: Unpigmented at hatching.[34] Eye pigmented at 4.1–4.4 mm in specimens 55–70 hours old; [39] development of eye pigment also described as faint at 66 hours, dusky at 90 hours, silvery at 102 hours, and golden at 138 hours. Pigment over gas bladder at 114 hours, and "trunk" at 162 hours.[34] In specimens 5.0–5.1 mm TL (115 hours old) 10 melanophores dorsal to gas bladder, 3 near anus (one of these supra-anal), and 2 on head. At 6.0–6.3 mm stellate melanophores on dorsum, ventral part

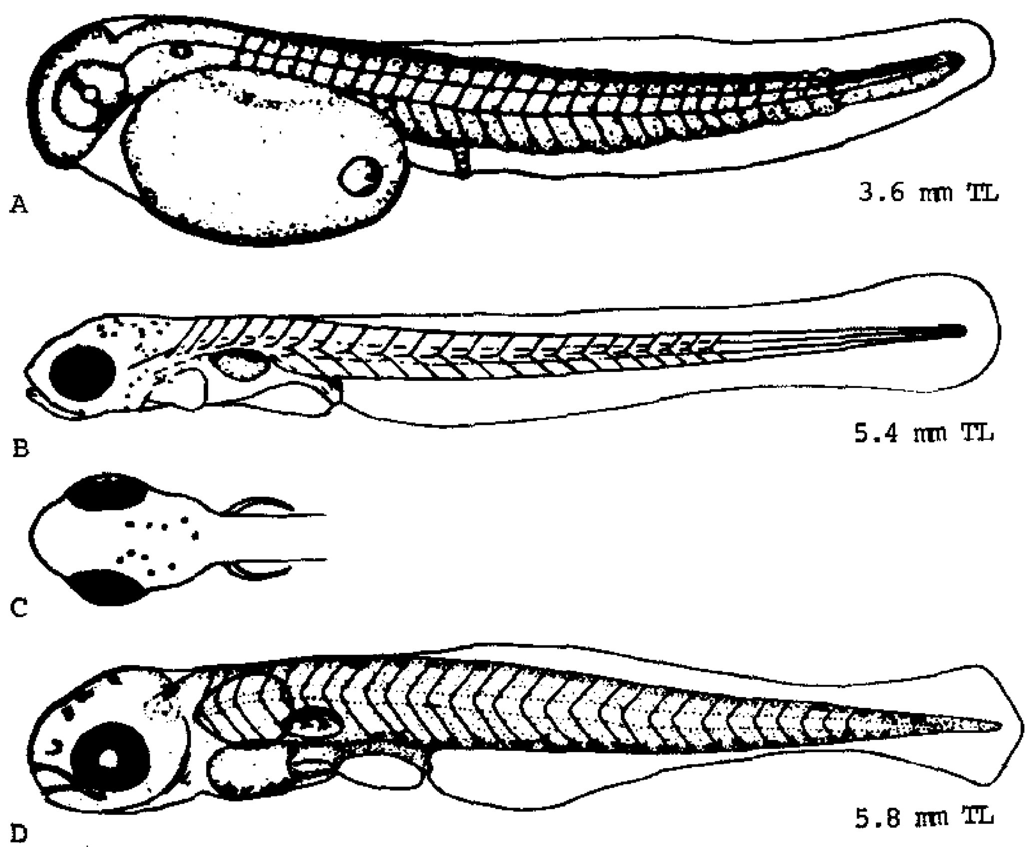

Fig. 112. *Lepomis cyanellus*, Green sunfish. A. Yolk-sac larva, 3.6 mm TL. B. Larva, 5.4 mm TL. C. Detail of head of A, dorsal view. D. Yolk-sac larva, 5.8 mm TL. (*A, D, Taubert, B. D., 1977: fig. 1. B, C, Meyer, F. A., 1970: fig. 5.*)

of yolk sac, above gas bladder, and in a ventral row from immediately anterior to anus to past last myomere; contracted melanophores increased on head.[39]

LARVAE

Minimum length uncertain, but yolk absorbed in 282 hours or less to 292 hours at 25.6–28.3 C,[2] and feeding evident at 3–5 days.[33] Minimum size described 5.3 mm, although specimens as small as 4.2 mm are free swimming.[1] Length at "swim-up" 6.0–6.3 mm.[39]

At 5.5 mm snout-vent length 3 1/7 times in TL.

Preanal myomeres, 11–13; postanal myomeres, 15–17.[39]

Remnant of preanal finfold still evident at 10.2 mm. Incipient rays in dorsal and anal fins at 7.0[1]–9.1 mm. Principal rays in caudal fin at 7.8–9.1 mm, procurrent rays at 8.6–9.4 mm.[39] Pectorals without rays at 10.2 mm.[1] Pelvic buds evident in some specimens at 8.3–9.1 mm,[39] but in others apparently still not formed at 10.2 mm.[1]

Pigmentation: In a specimen 282 hours old (from fertilization) a definite row of evenly spaced melanophores ventrally between anus and tip of tail.[34] At 5.5 mm chromatophores on top of head, in region of future operculum, over gas bladder, and, apparently, over gut just before anus; eye heavily pigmented; no pigment on body.[1] At 7.8–9.1 mm melanophores on cheeks and caudal membrane, a row of melanophores along lateral line. At 8.6–9.4 mm melanophores on dorsal and anal membranes and on lips.[39] At 10.2 mm pigment less distinct on gas bladder but increased on head; a definite mid-lateral row of pigment from head to base of tail;

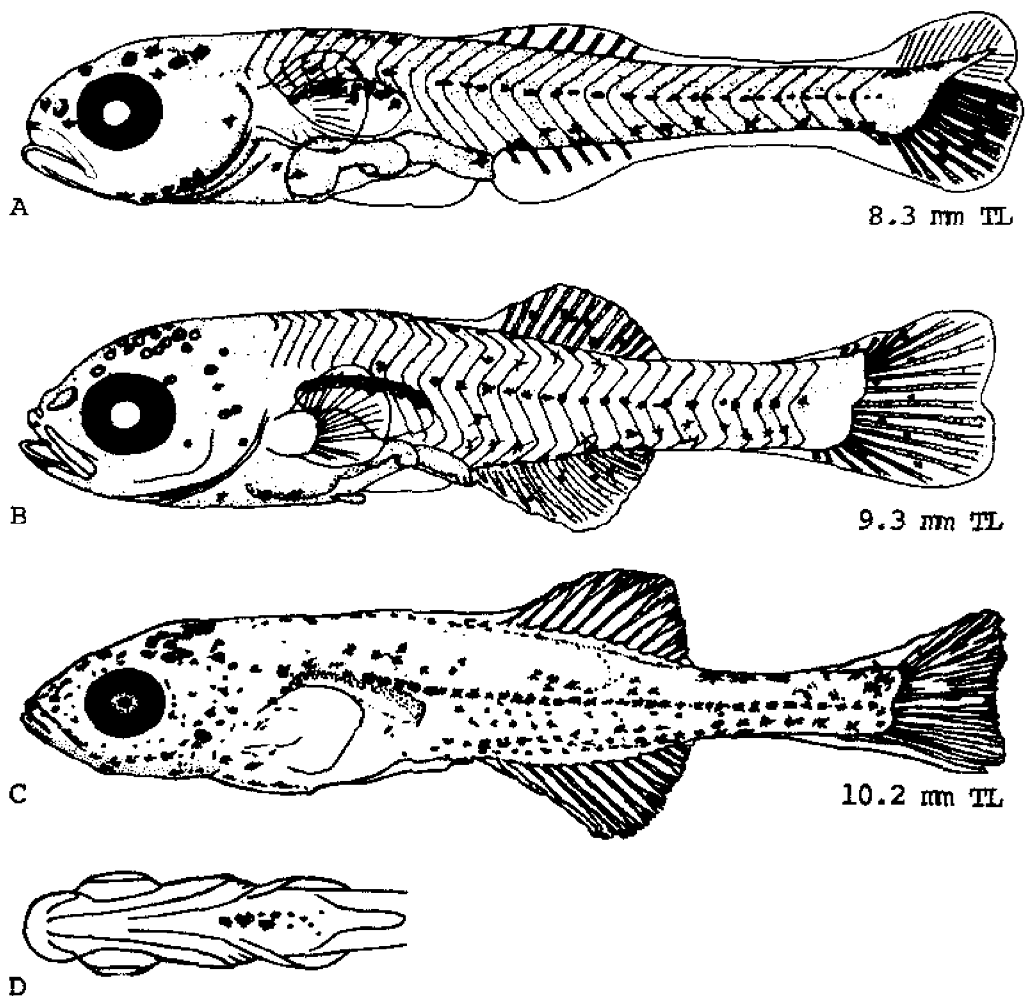

Fig. 113. Lepomis cyanellus, Green sunfish. A. Larva, 8.3 mm TL. B. Larva, 9.3 mm TL, pelvic buds evident. C. Larva, 10.2 mm TL. D. Ventral view of head of D. *(A, B, Taubert, B. D., 1977: fig. 2. B, C, Meyer, F. A., 1970: fig. 5.)*

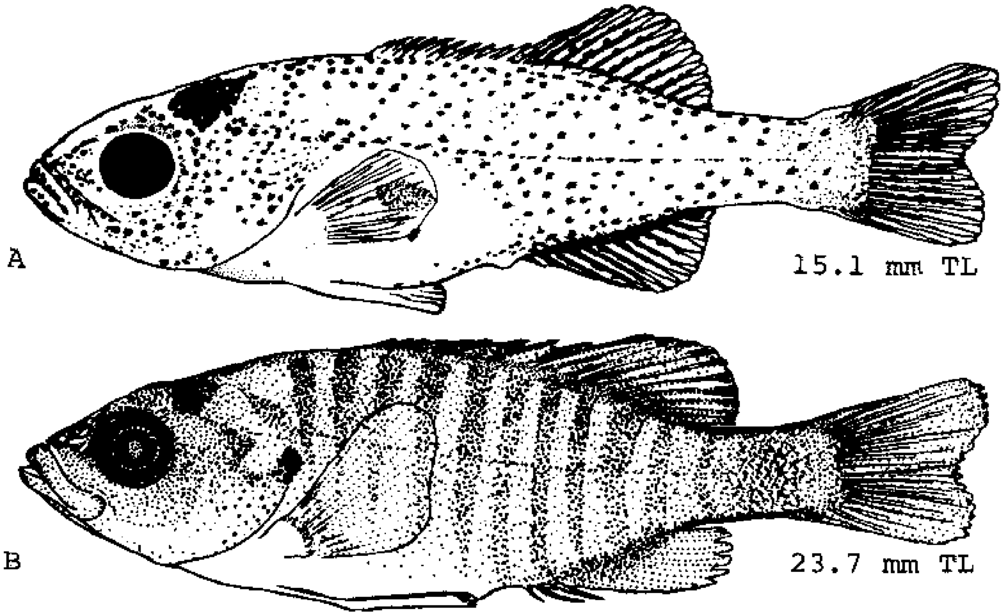

Fig. 114. *Lepomis cyanellus,* Green sunfish. A. Juvenile, 15.1 mm TL. B. Juvenile, 23.7 mm TL. (*A, B, Meyer, F. A., 1970: fig. 5.*)

pigment on lower part of body between anus and tail in indefinite rows; scattered pigment on upper side of body and along dorsal ridge; a characteristic elongate pigment patch mid-ventrally between pectoral fins.[1] Larvae in life described as looking like yellowish or blackish spots on stones and plants.[33]

JUVENILES

Minimum size described, 15.1 mm.

Pigmentation: At 15.1 mm large, widely spaced chromatophores over body except breast region; a heavy blotch of pigment on top of head; large chromatophores on lips and along proximal two-thirds of dorsal and anal fins; mid-lateral series of spots less distinct than in earlier stages. At 23.7 mm dark pigment developed at tip of opercle; a series of narrow lateral bands, each about as wide as the interspaces; posteriormost lateral bands extended to ventral line; pigment developed throughout dorsal, anal, and caudal fins; a dark blotch still evident on top of head.[1] In young dorsal and anal fins sprinkled with brownish red, dorsal fin with a dark blotch posteriorly. A half-grown individual (size unspecified) had light bands on the head and light blotches within the dark lateral bands.[11]

AGE AND SIZE AT MATURITY

Minimum age at maturity, less than 6 months;[27] minimum length at maturity, less than 50 mm.[30]

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Lepomis gibbosus (Linnaeus), Pumpkinseed

ADULTS

D. X to XI,[44] 10–12; A. II [20] to III, 8–11; P. 12–14; [20] V. I, 5; [35] scales in lateral line 34 [22]–47,[21] above lateral line 6 [20]–8,[21] below lateral line 13–17,[20] on cheek 4–5; [15] gill rakers on upper arm of first arch 3 [41]–4,[44] lower arm 8–11; [22,42] branchiostegals 6–7; pyloric caeca 7–8; total vertebrae 28–29; [44] caudal vertebrae 18.[4]

Proportions as percent TL: Greatest depth 27.8–42.5, caudal peduncle depth 10.7–15.1, head length 26.1–31.5, dorsal fin base 45.6–49.6, anal fin base 22.8–25.7, pectoral fin length 20.5-30.0. Eye 21.7–36.1 percent head length.[44]

Body very deep,[44] strongly compressed; [20] head deep, narrow, and with pronounced hollow over eyes; mouth terminal, slightly oblique, small; [44] gape to anterior margin of eye in some specimens, to anterior margin of pupil in others.[22] Teeth in brush-like patches on jaw; a single row of teeth on vomer; [44] palatine teeth absent.[14] Lateral line complete, high and with long shallow arch over pectoral fin.[44]

Pigmentation: Olive,[41] grass-green, emerald,[15] golden brown,[41] dusky [43] or golden above, mottled with rust, orange,[8] gold, or emerald; [15] lower sides golden; sides of body flecked with olive, orange, or red and with blue, green, or emerald reflections, sometimes with 7–10 vertical dark bands; [8,44] sides also described as having numerous blotches of olive or copper [15] and irregular, wavy, interconnecting blue-green lines; [44] ventral surfaces orange-yellow,[15] bronze, red-orange,[44] golden,[22] or coppery amber; [43] head with 4–5 [15] wavy blue-green stripes; [43,44] opercular flap velvety black [15] with narrow border of white, yellow, orange, or blue and a small half-moon of bright red, orange, pink, or yellow at tip; [24,44] iris bronzed, reddish or brownish; [38,43] eye also described as having a black pupil surrounded by an indistinct golden ring; peritoneum silvery. Leading edge of dorsal spines black; [44] soft portion of dorsal fin with vague spots of orange, yellow, red, dark brown,[8] or olive,[15,44] these sometimes arranged in 5–7 oblique rows,[8] and with trailing edge of yellow or blue-green; [44,45] anal fin with orange, yellow, red, or dark brown spots,[8] its trailing edge whitish, yellowish,[45] or blue-green; [44] caudal fin brownish olive basally, bluish green distally,[8] and with vague orange to olive spots; [44] pelvic fins black in males, yellow in females; [5,19] pectoral fins light yellow,[22] amber, or clear.[44]

Maximum length: Ca. 300 mm.[21]

DISTRIBUTION AND ECOLOGY

Range: Southeastern Canada from Quebec to Ontario and southcentral Canada from western Ontario to eastern Manitoba; absent immediately north of Lake Superior; south from Manitoba through parts of North and South Dakota to southwestern Missouri; due east from Missouri to Appalachian Mountains then north to Ohio and western Pennsylvania; south, east of the Appalachians, to Georgia.[44] Also introduced in California, Colorado, Wyoming, Montana, Washington, Oregon, southern British Columbia, and Vancouver Island; and in Europe in England, France, the Netherlands, Belgium, Luxemburg, Germany, and Czechoslovakia.[14,23,30,44]

Area distribution: Throughout Chesapeake Bay drainage to Havre de Grace, Maryland; [6,22] Delaware; [47] New Jersey.[46]

Habitat and movements: Adults—in clear water [8] in weedy lakes,[23] shallow bays of larger lakes,[44] ponds [23,37] (including barrier beach ponds, JDH), impoundments,[30] streams,[4,23,41] creeks,[30] rivers,[5] and spillpools [30] over bottoms of sand, gravel,[5] rock,[24] or muck covered with organic debris; [8] typically in or adjacent to aquatic vegetation.[4,5,12,24,44] Winter in deep water in schools.[42] Maximum recorded salinity, 18.17 ppt.[22] Normally at temperatures of 5.0–32.5 C,[30] with preference for 31.1–31.7 C; become inactive below 10.0 C.[45]

Maximum depth, 12.2 m.[44]

Larvae—at hatching lie on sides on bottom, swim toward surface, fall back; [7] larvae also described as attached to plants.[40] Remain motionless in nest for 2 days, then begin to creep about nest; at 5–6 days rise to surface.[40]

Juveniles—specimens less than ca. 75 mm long in shallow water in vegetation or in clear open water over sandy bottom.[5] Young in schools; [24] also known to overwinter in shallow pools after ponds have dried up.[48] Maximum salinity 7.2 ppt; [3] also recorded from water having surface variance of 0.2–0.6 ppt, bottom variance of 12.7–14.3 ppt.[28] Temperature range, 5–29 C.[3] Fry rarely at surface, most frequently at 1 meter, usually close to substrate.[18]

SPAWNING

Location: In ponds, lakes, creeks, and slow moving streams [5,10,44] over bottoms of gravel, small flat rocks and mixed gravel,[24,29,34] sandy gravel,[37] rubble,[34] sand,[4,29,40] clay,[5,44] muck,[29] marl,[31] and mud,[24] or various combinations of most of the above; [10] sometimes in areas with exposed roots, or with overlay or sticks, leaves, and/or shells; [29] in one series of observations 75% of nests over shale and gravel, mud least frequently used.[16] Sometimes in areas with no plants; sometimes in dense growths of algae,[31] or among other vegetation,[8,12,24] particularly emer-

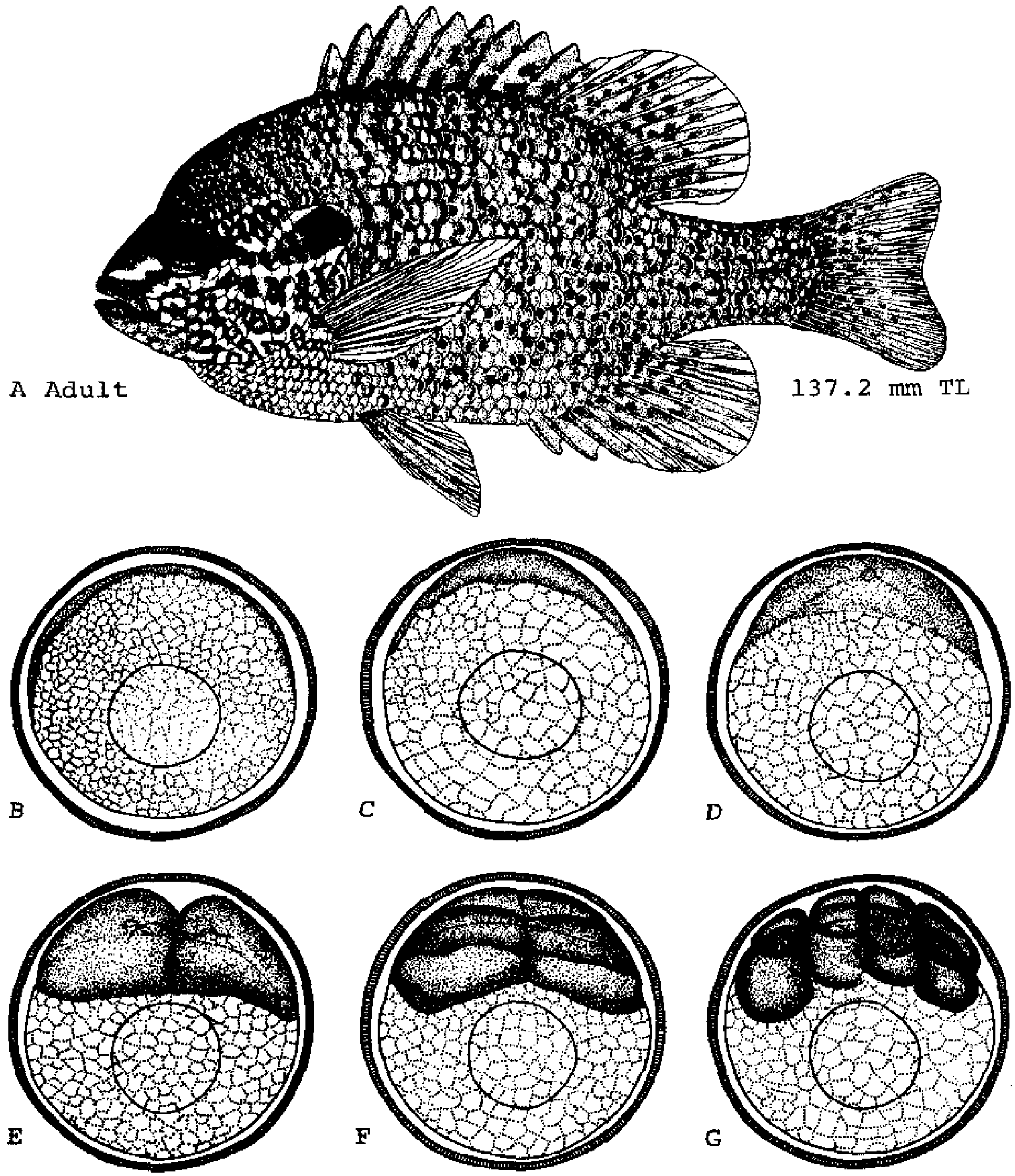

Fig. 115. *Lepomis gibbosus*, Pumpkinseed. A. Adult, 137.2 mm TL. B. Early blastodisc, 15 minutes after fertilization. C. Blastodisc at 45 minutes. D. Late blastodisc, 60 minutes. E. 2-cell stage, 1 hour and 15 minutes. F. 4-cell stage, 1 hour and 45 minutes. G. 8-cell stage, 2 hours and 40 minutes. (*A, Trautman, M. B., 1957: fig. 139. B-G, Balon, E. K., 1959: fig. 10.*)

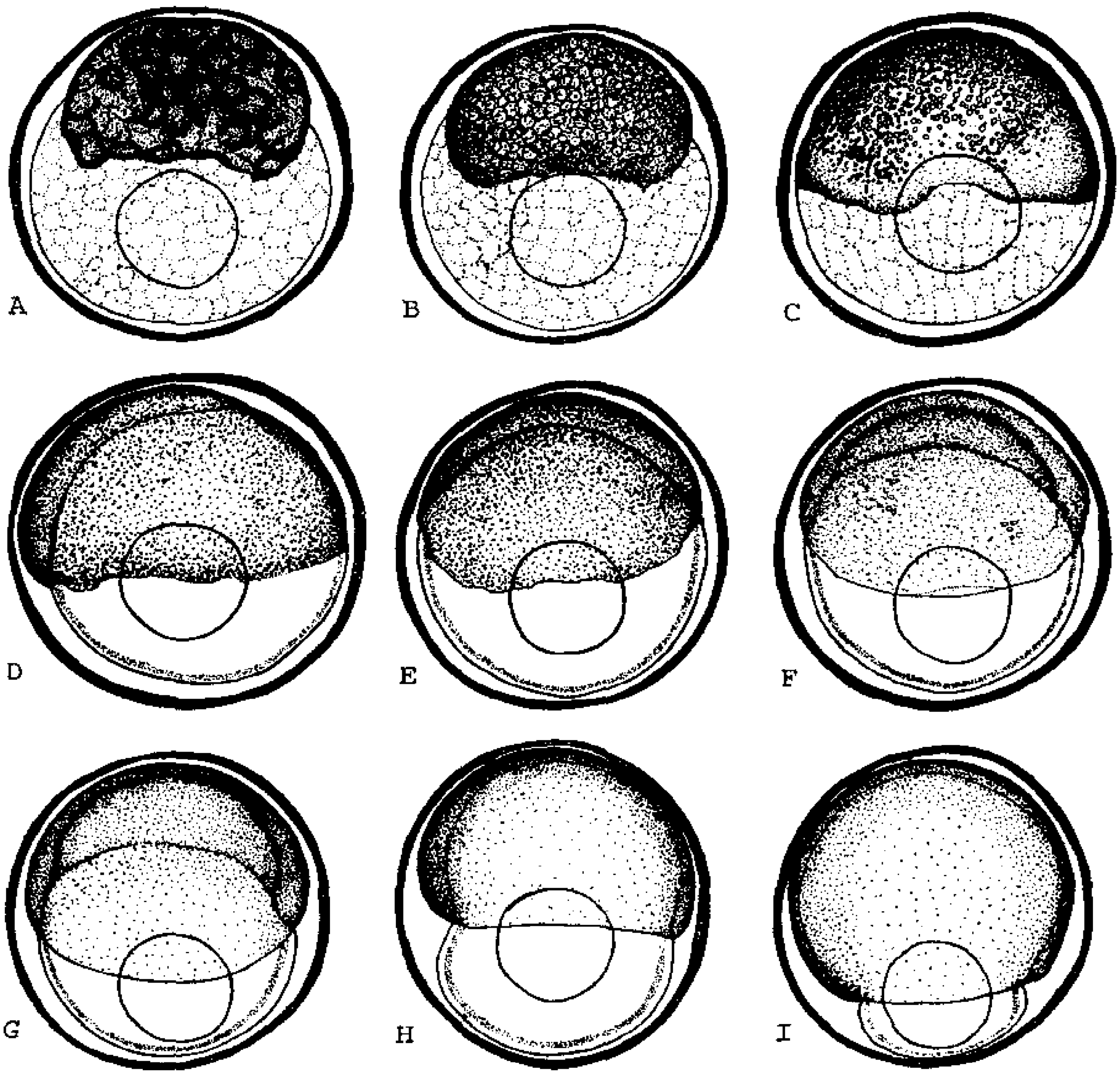

Fig. 116. *Lepomis gibbosus*, Pumpkinseed. A. Early morula, 4 hours, 10 minutes. B. Late morula, 5 hours, 40 minutes. C. 8 hours, 30 minutes. D. Early gastrula, 10 hours, 15 minutes. E. 11 hours, 15 minutes. F. 12 hours, 15 minutes. G. Gastrula extended approximately to equator of yolk, 13 hours, 30 minutes. H. Yolk noticeably constricted by advancing gastrula, 15 hours, 15 minutes. I. Gastrula with large yolk plug, 16 hours, 45 minutes. (*A-I, Balon, E., 1959: fig. 11, a-f; fig. 12, a-c.*)

gent plants[16] such as bulrushes[5] and reeds;[17] often[31] (but not always[16]) near solid objects on bottom;[31] avoid total shade; distance from shore, 300 mm[16] to 10 meters.[42] Sometimes spawns in nest of other species.[29,31]

Nest: Typically in small groups (2–3 nests), and sometimes as close together as 76–102 mm; rarely solitary;[29,31] circular[5] or oval (in one series of observations 2 nests round, 24 oval).[16] Nest usually with rim of silt;[31] bottom of nest sometimes with exposed roots and remnants of water plants;[39] in areas of dense vegetation, nest with escape channel.[16] Diameter of nest highly variable, ca. 100[44] to ca. 915 mm;[5] with smallest nests apparently in shallowest water;[31] in one series of 36 nests overall dimensions varied from 406–914×305–762 mm (average 643×523 mm);[16] maximum reported nest depth (rim to bottom), 76 mm.[17] Reported depth of nest sites 13[16] to 914 mm.[31] In Lake Erie two kinds of nests have been reported: large, usually oval nests up to 686×914 mm, and small round nests having average diameter of 178 mm.[17]

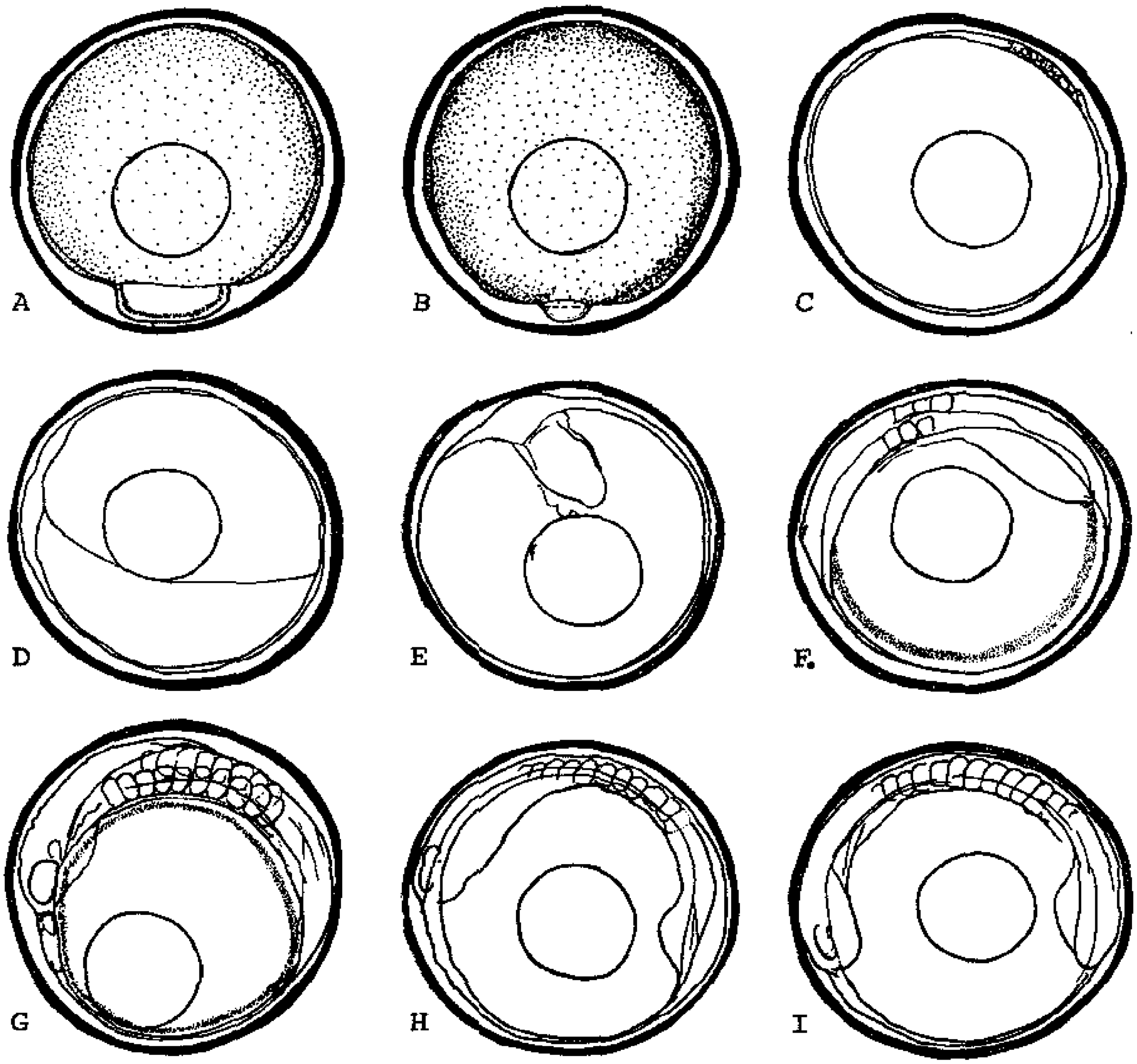

Fig. 117. *Lepomis gibbosus*, Pumpkinseed. A. Yolk plug reduced, 17 hours, 55 minutes. B. Yolk plug still evident, minute, 18 hours, 40 minutes. C. Yolk plug closed, 19 hours, 15 minutes. D. Head differentiated, 21 hours, 25 minutes. E, F. 3-somite stage, 22 hours. G. 10 somites formed, eyes developing, 22 hours, 45 minutes. H. 11 somites, Kupffer's vesicle well defined, 24 hours, 25 minutes. I. 13 somites, 28 hours, 45 minutes. (*A-I, Balon, E., 1959: fig. 12, d-f; fig. 13, a-f.*)

Season: In Delaware spawning occurs May 12 to August 11, peak mid-May through June; [30] in New Jersey late May into August; [2,27] in New York late May to late July,[5,14,16,31] peak activity in June; [44] in Connecticut early June to mid-August, peak in mid-July; [4] in Illinois begin end of May; [28] in Michigan May 31 to July 18; [29] in Canada early May (2–4 weeks before bluegills) [42] to end of August; [44] in Europe (generally) May through August; [49] in Czechoslovakia, May 25 to July 20; [39] under aquarium conditions nesting behavior in December.[10] Spawns 3 times or more per season at intervals of 20–30 days.[49]

Time: In nature reported between 1215 and 1305 hours,[13] and in evening; [40] under aquarium conditions at 1700 hours.[10]

Temperature: Range during nesting and/or spawning activity 13 [42]–27.8 C; [52] optimum spawning temperature 21–24 C.[9]

Salinity: Up to 10 ppt.[30]

Fecundity: Females 2–5 years old and 61–92 mm long. 600–2923; other estimates to 5000.[44] Number of fry/nest 1506–14,639,[29] average 8074.[34]

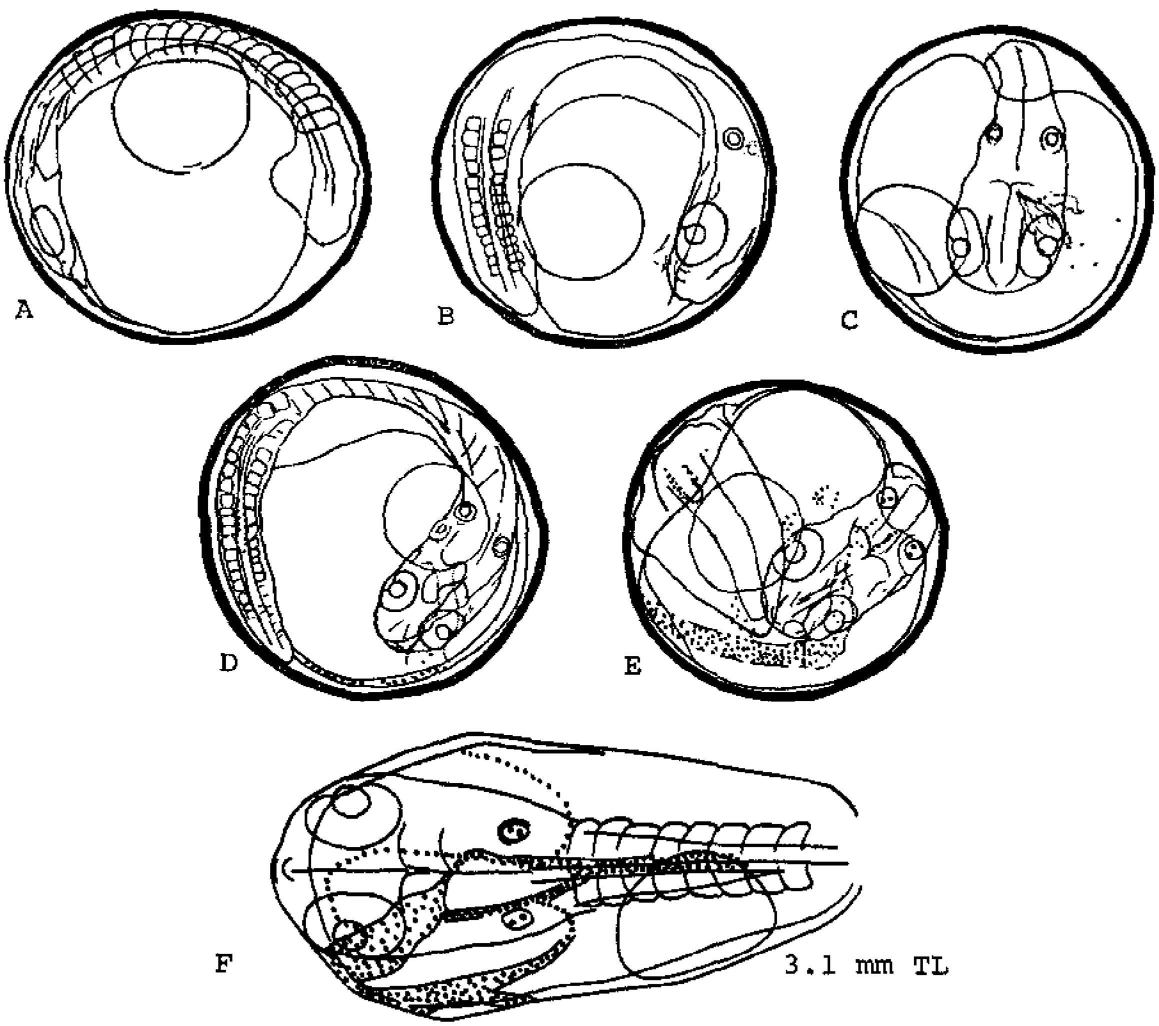

Fig. 118. Lepomis gibbosus, Pumpkinseed. A. 18 somites, eye pouches closed, tail barely separated from yolk, 29 hours. B, C. 30 somites, otocysts developed, heart beat and body movements established, 36 hours, 30 minutes. D. 39 hours, 25 minutes. E. Otoliths developed, 43 hours, 30 minutes. F. Yolk-sac larva immediately after hatching, 3.1 mm TL, 47 hours, 30 minutes. (*A-F, Balon, E., 1959: fig. 14, a-e; fig. 15.*)

EGGS

Location: Demersal, attached to soil particles, rocks, gravel, roots, sticks, and aquatic vegetation.[4,5,9,12,35,37,44]

Fertilized, possibly unhardened eggs: Diameter 0.6–1.0 mm.[49]

Fertilized, water-hardened eggs: Transparent (JDH) or "whitish";[32] adhesive;[13] diameter 0.8–1.2[9,33] (although one author reports an average size of ca. 1.2 mm[2]); capsule thick, laminated; a single large bright canary yellow oil globule and several extremely small ones; oil globule diameter *0.37–0.40* mm[2,7] (also expressed as ca. *30%* yolk diameter);[9] perivitelline space narrow, 0.05 mm.[7]

EGG DEVELOPMENT

At 19.0–24.9 C (average morning temperature *21.1 C*, average evening temperature 23.2 C):

15 minutes	blastodisc developing as thin layer.
45 minutes	blastodisc still more or less flattened over yolk.
60 minutes	blastodisc peaked up over yolk.
1 hour, 15 minutes	2-cell stage.
1 hour, 45 minutes	4-cell stage.
2 hours, 10 minutes	8-cell stage.

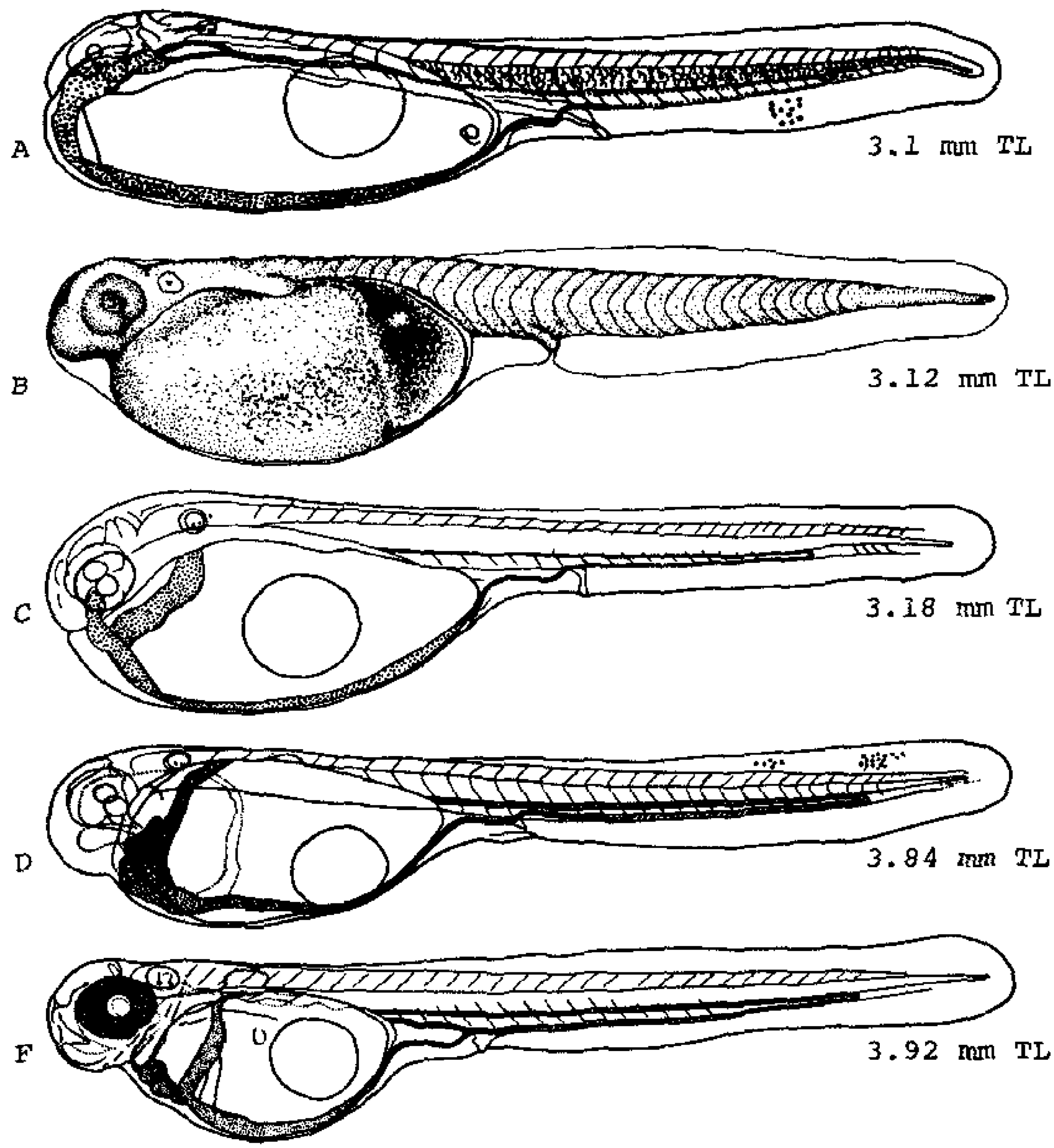

Fig. 119. *Lepomis gibbosus*, Pumpkinseed. A. Yolk-sac larva, 47 *hours, 30 minutes after fertilization, ca.* 3.1 mm TL. B. Yolk-sac larva, 3.12 mm TL. C. Yolk-sac larva, 52 hours, 25 minutes, 3.18 mm TL. D. Yolk-sac larva, 60 hours, 45 minutes, 3.84 mm TL. E. Yolk-sac larva, eye pigment forming, 3.92 mm TL. (*A, C-E, Balon, E., 1959: figs. 16–19. B, Anjard, C. C., 1974: 185.*)

2 hours, 40 minutes	16-cell stage.
4 hours, 10 minutes	early morula.
5 hours, 40 minutes	late morula.
8 hours, 30 minutes	blastoderm spreading down over yolk.
10 hours, 15 minutes	early gastrula.
12 hours, 15 minutes	blastoderm to equator of egg.
13 hours, 30 minutes	blastoderm below equator, yolk slightly constricted.
15 hours, 15 minutes	yolk at maximum constriction.
16 hours, 45 minutes	*yolk plug stage.*
18 hours, 40 minutes	*yolk plug greatly reduced.*

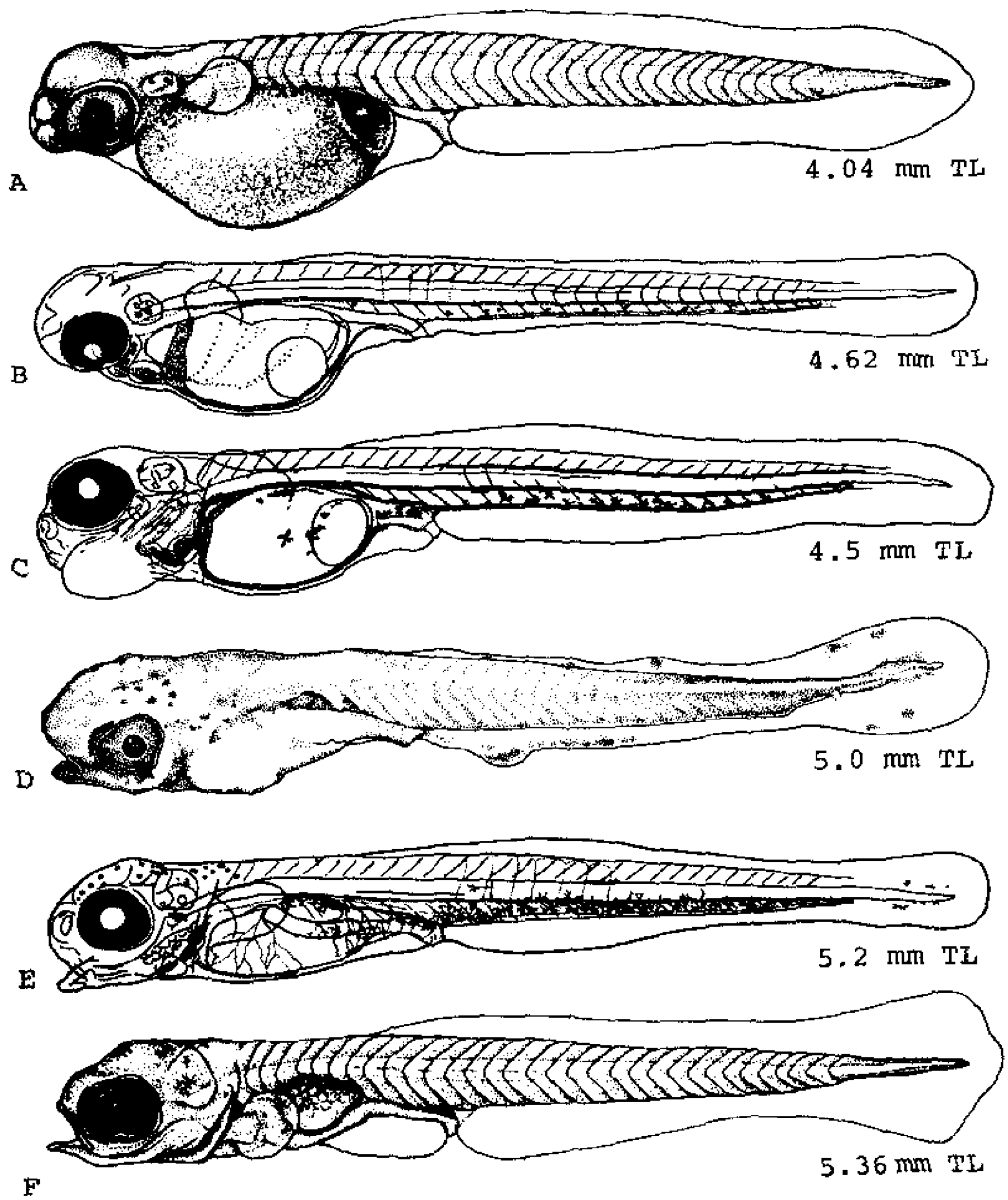

Fig. 120. *Lepomis gibbosus*, Pumpkinseed. A. Yolk-sac larva, 4.04 mm TL. B. Yolk-sac larva, eye fully pig-
mented, pigment developing ventro-caudally, 108 hours, 15 minutes, 4.62 mm TL. C. Yolk-sac larva, additional
pigment on yolk-sac and above gut, 132 hours, 15 minutes, 4.5 mm TL. D. Yolk-sac larva, pigment developed on
head, gas bladder visible, 5.0 mm TL. E. Yolk-sac larva, 157 hours, 15 minutes, 5.2 mm TL. F. Larva, 5.36 mm
TL. (*A, F, Anjard*, C. A., *1974, p.* 185. B, C, E, *Balon*, E., *1959: figs.* 20–22. *D, May, E. B., and C. R. Gasaway, 1967: fig. 39, Joan Ellis, delineator.*)

19 hours, 15 minutes	blastopore closed.
21 hours, 25 minutes	anlagen of head differentiated.
22 hours	3 somites.
22 hours, 45 minutes	10 somites, eye developing.
24 hours, 25 minutes	11 somites.
28 hours, 45 minutes	13 somites, Kupffer's vesicle developing.
29 hours	18 somites, tail free, optic vesicle closed.
36 hours, 15 minutes	29 somites, lens complete.
36 hours, 30 minutes	30 somites, otoliths evident, weak body movements, heartbeat established.
39 hours, 25 minutes	blood vessels well-developed over yolk.
Ca. 47 hours, 30 minutes	hatching.[7,39]

Incubation period: Variously stated as 2–3 days at 18–20 C;[49] 3[52]–4 days at 28 C;[10] and ca. 47.5 hours at temperatures which varied from 19.0–24.9 C;[7,39] 2.5 days at 1620 degree-hours.[49] A report of 5–10 days "depending on temperature"[50] is questioned (JDH).

YOLK-SAC LARVAE

Hatching length ca. 2.6[2]–3.1 mm.[7] Length at end of stage 4.5[9] to longer than 5.2 mm.[7]

Preanal myomeres 10–13, postanal myomeres 17–21, total myomeres 27[51]–35.

At hatching yolk mass egg-shaped; yolk still evident in some specimens at 5.2 mm. Early in stage oil globule at or slightly posterior to midpoint of yolk; at 5.2 mm oil globule dorsoventrally compressed. At 3.92 mm nostrils evident; at 4.5 mm gills and gill arches developing; lower jaw movable at 5.2 mm; position of otocysts shifted forward as development proceeds, at 3.1 mm TL, 0.22 mm behind eye, at 3.84 mm, 0.15 mm behind eye.[7] Pectoral buds evident at 3.12 mm;[9] at 4.5 mm pectoral fins well-formed, rayless, oriented diagonally rather than horizontally as in earlier stages.[7] Forward part of gut coiled at 4.5–5.0 mm;[9] gas bladder filled with air at 5.2 mm.[7]

Pigmentation: At hatching completely clear except for canary yellow oil globule. At 3.92 mm eye faintly pigmented. In a specimen 4.62 mm long and 108 hours 50 minutes old, eye completely black, a few single melanophores ventrally between anus and tail, yellow pigment on yolk and posterior part of gut, and pigment increased ventrally between anus and tail. At 5.2 mm yellow pigment on head, melanophores ventrally between anus and tail greatly increased, few melanophores around tip of notochord and above notochord about halfway between anus and tail, dorsal surface of gas bladder densely pigmented.[7]

LARVAE

Size range described, 4.5–5.36 mm TL.[9] Length at swim up 5.2 mm.[51]

Myomeres at 5.36 mm (derived from figure), ca. 12+19.[9]

Pigmentation: In a 5.0 mm larva from Oklahoma, several large pigment spots on side of head above eye,[11] although this pigment not evident in another slightly larger specimen (5.36 mm TL) from New York. At 10–15 mm no

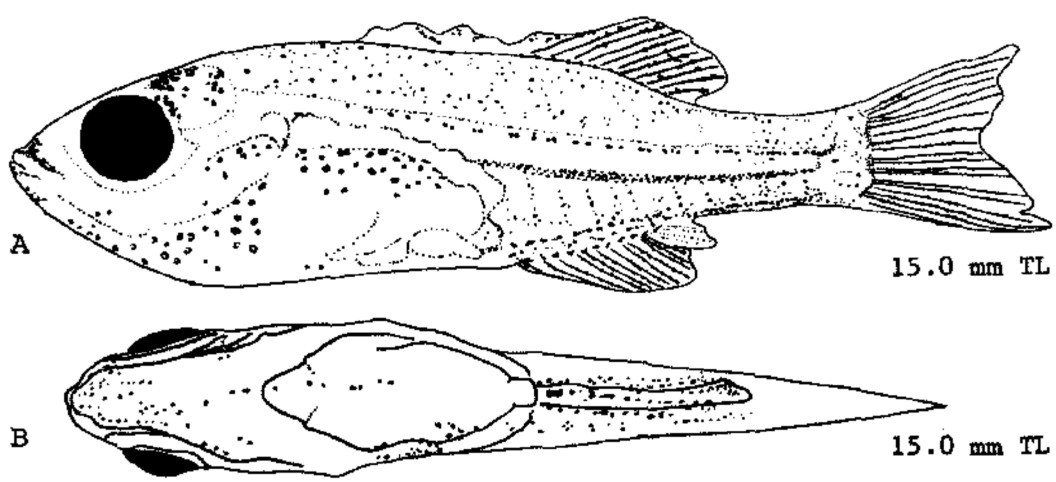

Fig. 121. Lepomis gibbosus, Pumpkinseed. A. Larva, 15.0 mm TL, lateral view. B. Larva, 15.0 mm TL, ventral view showing characteristic pigment on breast. *(A, B, Werner, R. G., 1966: figs. 4, 5.)*

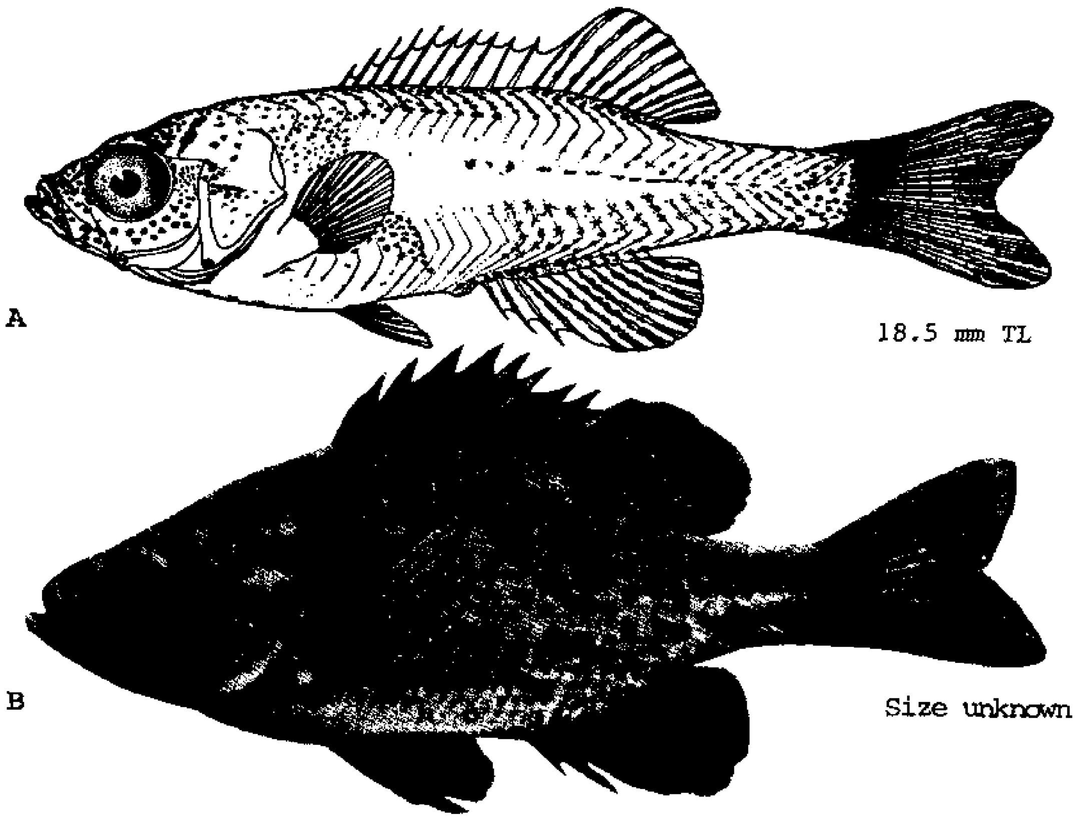

Fig. 122. *Lepomis gibbosus*, Pumpkinseed. A. Juvenile, 18.5 mm TL. B. "Young" (juvenile?), size unknown (although less than 75 mm TL). (*A, Fish, M. P., 1932: fig. 120. B, Sterba, G., 1967: fig. 812.*)

melanophores or only small circular ones on breast. In a 15 mm *specimen very little pigment on belly*, an indefinite double row of melanophores around anal fin.[48] Larvae with a prominent melanophore just above anus on each side, breast with few or no melanophores.[9]

JUVENILES

Size range described 16[38]–18.5 mm.[4]

Myomeres 10 + 18 at 18.5 mm TL,[4] vertebrae 12 + 18.48.

At 18.5 mm, length to vent 41% TL, HL 24% TL, diameter of eye 8% TL, greatest depth 24% TL, predorsal length 31% TL, preanal length 43% TL.[4]

Body ovate, very compressed; head depressed over eye; snout short; mouth small, oblique; maxillary to anterior margin of eye; origin of spinous portion of dorsal fin considerably anterior to anal fin.[4]

Pigmentation: Variously described. In a Delaware specimen 16 mm TL, 10 faint vertical bars indicated on body between head and caudal peduncle, these extending slightly below lateral line; no pigment in fins. In a larger specimen from Lake Erie (18.5 mm TL) no vertical bands *on body; body evenly covered with small black chromatophores* which follow margins of myomeres; heavy pigment around jaws, top of head, and cheeks; single linear spots along lateral line from above anal origin to caudal, and around bases of dorsal and anal fins; all fins with chromatophores, the least on pelvic and pectoral fins; belly colorless.[4] "Young" described as like females except that much of bright coloring replaced with silvery or light olive;[44] and "more bluish than adults" with pale olive brown dorsum, indistinct vertical bands, brownish emerald and blue markings on sides of head, pearly reflections in iris, pale translucent fins, and coppery white peritoneum.[43] Yearlings and 2-year-olds yellowish brown on back and sides, with prominent vertical bars on sides, and small orange spot on posterior edge of opercular flap.[42]

AGE AND SIZE AT MATURITY

Minimum age at maturity, 2nd summer when 1 year old;[1] minimum length at maturity, 60 mm in stunted populations.[31]

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Lepomis gulosus (Cuvier), Warmouth

ADULTS

D. X,[7] 9–11;[8] A. III, 8–9;[7] scales in lateral line 40–46,[10] in transverse series 17–18[17] (although also stated as 6–11[10]), on cheek 6–8;[20] gill rakers 8–9;[17,24] vertebrae 13+16.[20]

Greatest depth 1.7–2.9 times in TL;[8] eye diameter 4.0–4.5 times in head.[17]

Gape to center of eye or beyond;[14,26] teeth present on tongue, ectopterygoids, and entopterygoids.[11]

Pigmentation: Light yellow olive to dark olive green above, vermiculated with lighter, and with dull bluish, purplish and golden reflections.[8] Sides dark olive-green,[7,24] bluish green, blackish green, or orange-yellow;[8] sometimes with bluish[10] or purplish lavender sheen;[8] sides mottled[7] or barred with 6–11 chain-like double bands of dark olive,[8] bluish, or dusky[7] (these best developed in fish from clear vegetated water, absent in fish from turbid water[8]); upper sides sometimes thickly spotted with blue or red;[10] each lateral scale with a dark spot. Venter white,[8] greenish,[7] yellowish, or brassy;[24] described by one author as usually with slate tinge and/or mottling.[8] Opercular flap coppery above, lavender below;[26] a deep black blotch in upper corner of gill cover.[10] Three to five[26] bluish, lavender, or reddish streaks radiating from posterior margin of eye. Eye crimson to purplish. Vertical fins generally grayish to olivaceous and more or less regularly vermiculated,[7,8] the vermiculations sometimes forming ocelli,[26] and edged with white or yellowish white;[8] dorsal fin with a pale-bordered spot on last rays;[10] pelvic fins transparent to light olive,[26] mottled with dusky.[24] Spawning males bright yellow with red eyes, iridescent metallic blue opercular streaks, distinct vertical bars on body,[1] and an orange[8] or orange-red spot at base of last three dorsal fin rays; soft dorsal fin edged with white;[26] pelvic fins slate-colored.[8]

Maximum length: Ca. 330 mm.[8]

DISTRIBUTION AND ECOLOGY

Range: The Great Lakes region[12] eastward to tributaries of Allegheny River in Pennsylvania and westward to Wisconsin; southward through Mississippi drainage (including parts of Iowa and Kansas) to Gulf coast and along Gulf coast from Rio Grande to Florida; northward along Atlantic coast to southern New York (although northern limit of native range uncertain).[6,11,12,13] Introduced in California, Washington, Idaho,[27] and Puerto Rico.[19]

Area distribution: Introduced in Potomac River in 1895,[25] present on Maryland coastal plain (JDH).

Habitat and movements: Adults—recorded from both silt-free[8] and muddy, turbid water[1] in lakes,[5] ponds,[8] flood plain ponds,[15] marshes,[8] bayous,[24,28] small back water sloughs,[1] oxbows,[8] and streams,[5] over bottoms of mud, muck,[22] silt,[15] organic debris,[8] or sand;[22] most frequently recorded from areas of dense vegetation,[1,15] but also found in vegetation-free oxbows, lakes,[8] and flood plain ponds;[15] frequently hide in weed masses or near stumps or banks; avoid intense light;[1] in streams prefer base or very low gradients,[8] rarely found in fast moving water. Move to deep water in winter, but do not form winter aggregations.[1] Maximum salinity, 17.4 ppt (but usually under 1.5 ppt).[4] Maximum recorded temperature, 34 C.[6]

Larvae—guarded by male throughout early larval stages. At hatching lie on sides on bottom of nest,[3] may jump upward 2 or 3 cm from bottom within 36–48 hours after hatching;[1] by 5th day assume upright position and swim awkwardly,[3] or swim about nest in compact groups;[1] at 10 days (5.5–6.0 mm) leave nest,[3] remain in schools among dense submerged vegetation or in open water closely surrounded by plants.[1]

Juveniles—nonschooling;[3] predominantly inshore[9] in protected areas such as weed beds or around stumps; in streams hide under rocks; apparently remain in shallow water throughout the year.[1,3] Maximum salinity (specimens 69–72 mm long); 17.4 ppt.[18]

SPAWNING

Location: Occurs 0.3 m[3] to 4.6 m[5] from shore, in water 51–1525 mm deep, over bottom of mud, silt, silt covered with sticks and leaves, sand, rubble, rubble and detritus, shale,[1,23] or leaf mold;[3] apparently prefer soft substrate even when firm substrate available;[26] nest usually associated with tree roots, stumps, sticks, brush, or dense aquatic vegetation[1,3,16] (although also recorded from areas which were "almost free of vegetation"[23]).

Nest described as both in colonies (610–915 mm apart, sometimes confluent),[1,23] and solitary;[26] diameter 102–457 mm;[3] construction variable, in some cases irregular in shape and with practically no excavation,[23] sometimes excavated to depths of up to 125 mm; rarely a spherical chamber entirely within vegetation.[3]

Season: In Texas spawning occurs April to October;[1] in Florida, probably year round;[7] in Tennessee, May to September;[11] in Illinois May 15 to August 15[1,23] with peak nest building in early June[1] and spawning mostly complete by early July;[26] in Iowa late June to late July.[2]

Temperature: Minimum 21.1 C.[1]

Fecundity: 4500–63,200, with smaller fish tending to pro-

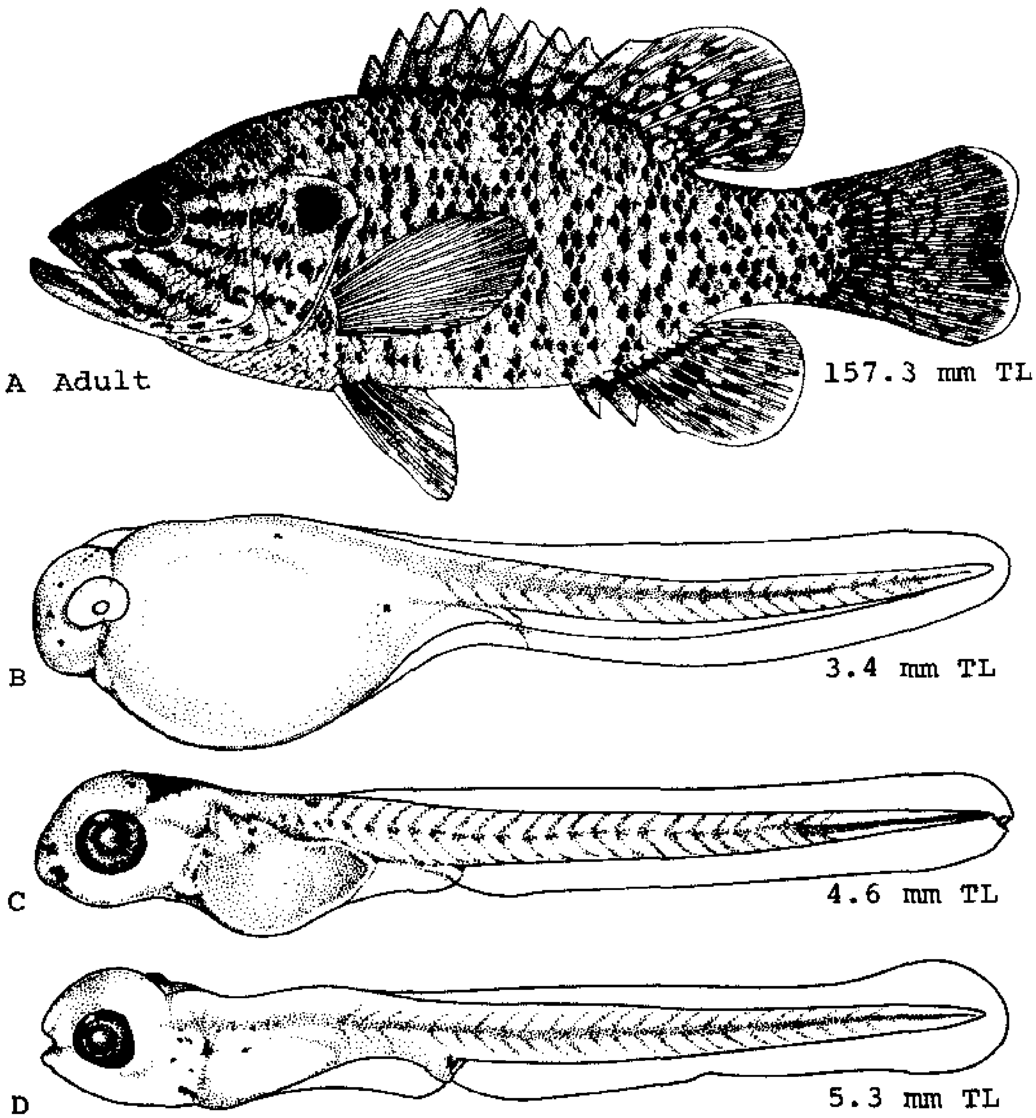

Fig. 123. *Lepomis gulosus*, Warmouth. A. Adult, 157.3 mm TL. B. Yolk-sac larva, 3.4 mm TL. C. Yolk-sac larva, 4.6 mm TL. D. Larva, 5.3 mm TL. (*A, Trautman, M. B., 1957: fig. 132. B-D, Larimore, R. W., 1957: fig. 14A-C, Elizabeth Ray Peters, delineator.*)

duce fewer eggs;[1] also up to ca. 126,000 ovarian eggs.[27]

EGGS

Location: Demersal, attached (JDH). Stick together in small clusters, also sometimes in linear bead-like arrangements on rootlets.[8]

Ripe ovarian eggs: Diameter 1.1 mm or larger.[1]

Nonwater-hardened fertilized eggs: Translucent, light amber, diameter 0.95–1.03 mm.[1]

Water-hardened eggs: Adhesive, clear amber, diameter 1.0–1.1 mm;[3] oil globule single, diameter 0.35 mm.[1]

EGG DEVELOPMENT

Development at 25.0–26.4 C:

3 minutes	thin perivitelline space developed.
33 minutes	blastodisc well-developed, slightly raised.
43 minutes	2-cell stage.

60 minutes	4-cell stage.
75 minutes	8-cell stage.
90 minutes	16-cell stage, blastomeres whitish, yolk very pale yellow, oil globule dark amber.
2 hours, 15 minutes	segmentation cavity formed.
2 hours, 30 minutes	blastoderm growing down over yolk mass.
About 11 hours	germ ring formed, thickened.
12 hours, 15 minutes	blastoderm covers all of yolk except yolk plug, yolk plug contains oil globule.
14 hours, 15 minutes	neural plate and neural groove distinct.
16 hours, 30 minutes	primordial embryo clearly evident.
25 hours	movement observed.
33 hours, 20 minutes to 36 hours	hatching.[1]

Incubation period: At unspecified temperature, 25–45 hours;[3] at 25.0–26.4 C, average 34 hours and 30 minutes (but with hatching lasting 2 hours and 40 minutes);[1] at average 26.2 C (SD 0.45), 29.4 hours (SD 1.55); at average 27.3 C (SD 0.33), 28.8 (SD 1.60) to 30.1 (SD 1.11) hours, $\bar{x}$ 29.4 (SD 1.55) hours; at average 27.6 C (SD 0.31), 28.4 (SD 1.56) to 29.6 (SD 1.17) hours, average 28.9 (SD 1.56) hours; and at average 28.1 C (SD 0.51), 28.9 hours (SD 1.56).[26]

Development is retarded by a drop to 13 C.[3]

YOLK-SAC LARVAE

Hatching length, 2.30–2.85 mm, with earliest hatchlings from a single batch of eggs the smallest. Yolk gone by 4th day of development (5.3 mm).[1]

Preanal myomeres 8–11, postanal myomeres 17–19, total myomeres 25–30.[29] Myomere counts at specific lengths: At 3.4 mm, 8 + 17; at 4.6 mm, ca. 10 + 19.[1]

At 3.4 mm length to anus 50% TL; at 4.6 mm, length to anus 43% TL, HL 14% TL, greatest depth 15% TL.[1]

Head initially deflected sharply downward over yolk. At 4.6 mm mouth indistinct,[1] branchiostegal elements forming, choroid fissure evident, pectoral lobes developed, incipient rays in caudal fin.[1]

Pigmentation: At 3.4 mm entirely without pigment; at 4.6 mm eye pigmented.[1]

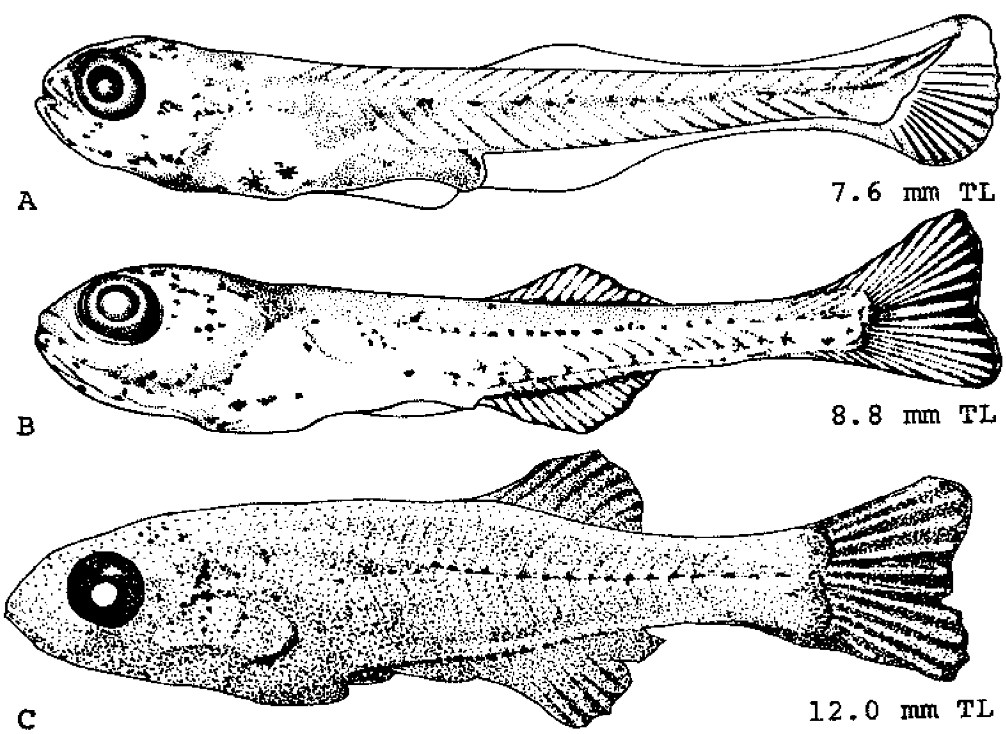

Fig. 124. *Lepomis gulosus*, Warmouth. A. Larva, 7.6 mm TL, urostyle flexed. B. Larva, 8.8 mm TL. C. Larva, 12.0 mm TL. (*A, B, Larimore, R. W., 1957: fig. 14, Elizabeth Ray Peters, delineator. C, Larimore, R. W., 1957, Tamiko Karr, delineator.*)

LARVAE

Size range described, 5.3–12.0 mm. Length at swim-up 5.3 mm.[29]

Myomeres, at 5.3 mm, 10 + 19; at 7.6 mm, 11 + 19. At 5.3 mm, length to anus 42% TL, greatest depth 11% TL, HL 17% TL, eye diameter 8% TL; at 7.6 mm, length to anus 45% TL, HL 20% TL, eye diameter 6% TL, greatest depth 15% TL; at 8.8 mm, length to anus 44% TL, HL 23% TL, eye diameter 8% TL; at 12.0 mm, length to anus 45% TL, HL 23% TL, eye diameter 8% TL, greatest depth 20% TL.[1]

At 5.3 mm cerebellum high, bulb-like; mouth oblique; gape to middle of eye. At 8.8 mm caudal peduncle long, narrow. Incipient rays in soft dorsal and anal fins at 5.3 mm; dorsal spines developing at 12.0 mm; pectoral fins rayless at 5.3 mm, rays evident at 7.6 mm; pelvic fins with indistinct rays at 12.0 mm. Preanal finfold evident as short keel in front of anus at 12.0 mm. Kidney visible through body wall at 5.3 mm; urostyle oblique at 7.6 mm.[1]

Pigmentation: At 5.3 mm, row of spots on either side of ventral finfold, two large chromatophores between bases of pectoral fins. At 7.6 mm, ventral pigment spreading as stellate chromatophores over entire ventral surface; heavy chromatophores over anus; a mid-lateral series of dashes; pigment evident at caudal base; 6 stellate chromatophores between pectoral bases; a row of 5 chromatophores on each side across branchiostegals; dark chromatophores scattered over head. At 8.8 mm, chromatophores along lateral line quite distinct, ventral spots larger, pigment on head increased.[1]

JUVENILES

Minimum length described, 15.7 mm.

At 15.7 mm, length to anus 44% TL, head length 28% TL, eye diameter 9% TL, greatest depth 24% TL.[1]

Pigmentation: At 15.7 mm pigment on head and caudal peduncle increased; large chromatophores scattered over back; belly essentially free of pigment; chromatophores developed behind eye and on dorsal, anal, and caudal fins.[1] "Young" also described as having barred pattern.[22]

AGE AND SIZE AT MATURITY

Reported as mature during second summer of life;[11] minimum size at maturity, ca. 75 mm.[1]

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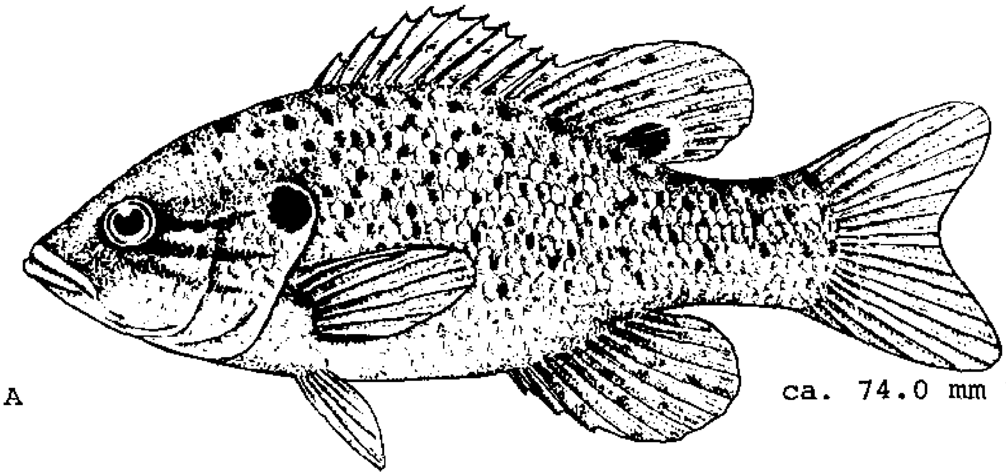

Fig. 125. Lepomis gulosus, Warmouth. A. Juvenile, ca. 74.0 mm TL. *(A, Sterba, G., 1957: fig. 985.)*

Lepomis macrochirus Rafinesque, Bluegill

ADULTS

D. IX to XI,[53] 10[27]–13[53] (reported averages, spines 9.94,[18] 9.98, rays 11.47,[53] 12.15[18]); A. II to III,[53,60] 8[54]–12 (reported averages, spines 2.99, rays 11.05,[53,60] 11.57[18]); P. 12[53]–15[54] (reported average 12.76,[18] 12.83[53]); V. I, 5;[48] scales in lateral line 36[53]–48[22] (reported averages 40.82,[53] 45.29[18]), above lateral line 5–8 (reported averages 6.34,[53] 7.44[18]), below lateral line 12[53]–16[34] (reported averages 13.58,[53] 15.40[18]), on cheek 4–6 (average 5.32); gill rakers on first arch 12–15 (average 13.68),[53] also stated as 12+4,[57] average rakers upper branch 11.79;[18] branchiostegal rays usually 6, rarely 6+5; pyloric caeca 6;[57] total vertebrae 28–30 (average 29.0), truck vertebrae 12[53]–13[55] or possibly 14,[54] caudal vertebrae 16–18 (average 16.99).[55]

Proportions as percent TL: Greatest depth 29.4–37.4, caudal peduncle depth ca. 12.0, head length 24.7–26.8, dorsal base ca. 40, anal base ca. 20, pectoral length 20.7–24.7. Proportions as percent HL: snout length 20–25, maxillary 26.3–31.6.[57]

Body laterally compressed, short, deep;[14] mouth terminal, slightly oblique, small;[57] gape rarely extended as far as anterior edge of eye; opercular flap flexible;[36,43] gill rakers moderately long[57] (longest raker almost 1/3 diameter of eye),[43] slender, blunt; brush-like teeth on jaws and vomer;[57] teeth lacking on tongue.[14]

Pigmentation: Green,[57] blue-green,[22] yellow-orange,[7] brownish[57] or almost black[22] above, sometimes with emerald-blue luster;[7] sides brown, iron-colored, green, yellow-green,[57,58] or bluish with silvery reflection,[7] usually with 5[27]–9[7] irregular, sometimes indistinct, dark or greenish vertical bars; breast pale white, yellow, brownish, or bright rusty or copper-red;[22,27,57] top of head dark greenish; sides of head brown to green with metallic blue and green overtones;[22,27,57] two broad bluish bands on ventral part of head;[43] opercular flap velvet black, often with iridescent blue at anterior edge; all fins except pectorals and pelvics greenish,[27,57] dark at bases, lighter distally;[14] a large dark spot at base of posterior rays of soft dorsal, and a similar spot on anal;[27,33,40] pectorals transparent, yellow or amber,[57] reddish at base;[27] pelvics dusky.[43]

Maximum length: 381 mm.[12,57]

DISTRIBUTION AND ECOLOGY

Range: Originally from St. Lawrence River south; west of the Appalachian Mountains to latitudes of Virginia; then east to the Atlantic coast; south from Virginia to southern Florida; west to northern Mexico; north from eastern New Mexico to eastern Minnesota and western Ontario; east, south of Lake Superior, to southern Ontario and Quebec. Also introduced in Connecticut,[57] the mid-Atlantic states (JDH), Washington, Montana, Utah, Wyoming, Colorado, and possibly other areas;[57] also introduced in Puerto Rico,[20] Africa,[57] Japan[53] and Europe.

Area distribution: Found in all tributaries of Chesapeake Bay[6] (presumably through introduction, JDH); also Delaware[5] and New Jersey.[58]

Habitat and movements: Adults—a schooling species[14,22,32,37,50] found in lakes, ponds,[12,26,27,30,35,57] reservoirs,[14] small rivers, creeks (including tidal creeks),[57] streams,[12] and spillpools[42] over bottoms of sand, gravel,[57] or muck;[7] usually associated with dense growths of aquatic vegetation;[12,22,57] prefer nonflowing clear water;[7] typically in shallow water near shore,[57] but larger individuals in more open water.[38] Temperature range, 5.0[62]–33.5 C[26] or possibly as high as 35 C.[22] Maximum salinity reported as 18 ppt,[6] but in experimental work, 13.9–16.9 ppt was lethal.[42]

Typically occupy home ranges not exceeding ca. 38 m of stream[23] but in winter move into somewhat deeper water (JDH). Winter aggregations break up at 10 C, with males moving inshore before females.[11,57] In spring some individuals move up sluggish streams or into channels. There are apparently some diurnal inshore-offshore movements.[22] When displaced will home for distances of up to 0.67 km.[59]

Maximum depth, 22 m,[30] but during summer stratification usually no deeper than 2.1[61]–3 m.[65]

Larvae—initially in nest (JDH); at hatching sometimes swim in circles on sides;[14] prior to free swimming stage make periodic vertical migrations to surface (aquarium studies);[9] after leaving nest may hide in vegetation,[64] or become concentrated in shallow coves,[1] although lake populations typically move offshore to limnetic zone: patchy distribution in epilimnion suggests aggregations.[64] Initially at bottom in shallow water (JDH), later in surface water near shore.[67] Taber found larvae 6–12 mm long at all depths, but concentrated near bottom; on the other hand Werner found larvae 10–12 mm concentrated in upper 2 m of epilimnion.[64]

Rise from nest at time of yolk absorption[14] (or at length of ca. 5.0 mm);[31] at temperature of 23.5 C become free swimming 144–153 hours after fertilization;[63] after leaving nest move offshore to limnetic zone arriving at 10–12 mm.[64]

Juveniles—move in schools, particularly at sizes greater than 14.4 mm;[1,14] initially in limnetic zone, later in lit-

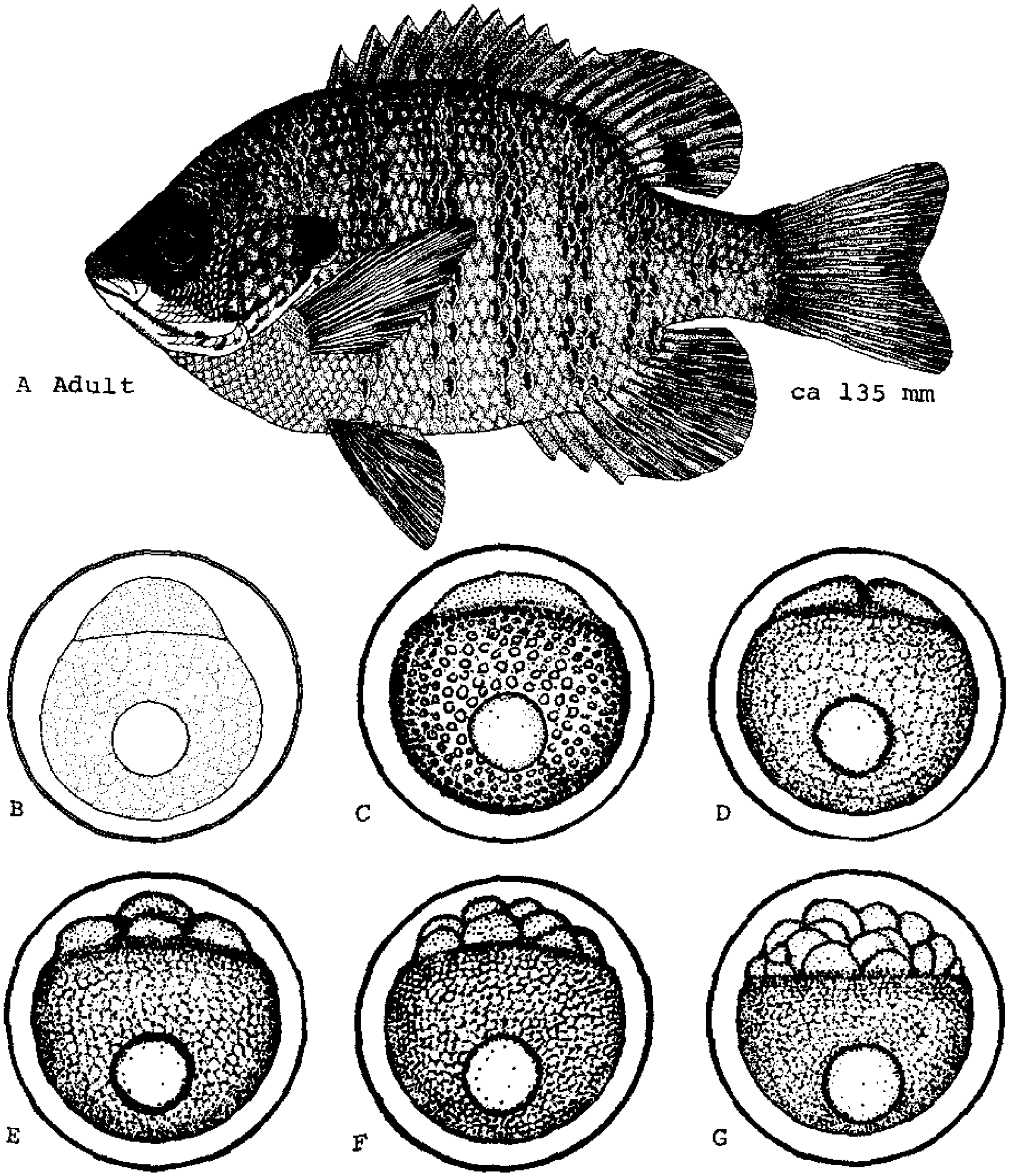

Fig. 126. ***Lepomis macrochirus***, **Bluegill.** A. Adult, ca. 135 mm. B. Early blastodisc, age unknown. C. Late blastodisc, age unknown. D. 2-cell stage, 35 minutes. E. 4-cell stage, 55 minutes. F. 8-cell stage, 1 hour, 17 minutes. G. 12- to 16-cell stage, 1 hour, 20 minutes. (*A, Trautman, M. B., 1957: fig. 134. B, Carver, D. M., 1976: fig. 1A. C-G, Morgan, G. D., 1951: pl. 1, figs. 1-5.*)

toral zone;[31,64] remain near shore in winter.[12] While in limnetic zone restricted to upper 3.5 m.[31,64] Recorded temperature range, 5.0[5]–29.5 C.[46]

At 20–25 mm, after 3–4 weeks in limnetic zone, return to littoral zone; larger fry make diurnal inshore-offshore movements.[31,64]

SPAWNING

Location: Near shore, usually in shaded areas[12] as near overhanging willow trees[10,62] over bottoms of gravel,[22] pebbles,[28] sand,[10,12,51] marl,[28,41] mud,[10,51] and muck[41] at depths of 5 cm[63] to 4.6 m,[47] but generally within the 1[62]–2 m contour;[28] in one study nest at depths of 13–109 cm, with average of 63.5 cm;[25] shallow nest constructed by young fish, deeper nest by older fish;[47] spawning typically in barren areas,[12] rarely among aquatic vegetation such as *Potamogeton*.[14,28]

Nest: Nests usually in clusters,[10,25,28,47] rarely solitary;[14] clusters may contain up to 54 nests,[41] and 30 nests have been counted in an area of 15 square meters;[47] within a cluster nests may be up to 0.9 m apart,[12] but in one study of two areas average distance between nests were 32±12 cm and 50±19 cm.[62] Nests round[10,51] or oblong;[28,41] typically dug down to firm bottom of gravel, sand, or mud,[57] but bottom may contain grass, twigs, roots,[10,41,51] or shells.[28] Depth from rim to base varies from 1.3 cm[10,51] to 15 cm;[22] if nest bottom contains thick roots, nest shallow (30–40 mm); if bottom of marl, nest deeper (up to 150 mm).[28] Nest diameter highly variable, ca. 15[12]–91 cm.[28] May spawn in nest of other species.[41]

Season: In Puerto Rico year round;[20] in Lake Texoma early May to late September;[1] in Texas peak around April 20, continues into September;[16] in Alabama April to October;[52] in Missouri early June to September;[40] in "southern states" early May to late September;[17] in Delaware late May through August;[42] in New Jersey in July; in New York May to early August;[10,12,44] in Ohio early May to August 20, with several distinct peaks throughout season;[14,24] in Wisconsin late May to early August, with peak in June;[22,41] in Michigan May 17 to August 9;[21,41] in Illinois May[10,12,39,51,52] to September 18;[43] in Indiana late May[64] to early August (but this based on ripe adults)[9] with peak activity in late May and early June;[64] in Canada May 21 to August 5 (2–4 weeks later than pumpkinseed),[62] with peak activity in July;[57] in Japan May 10 to July 22.[56]

Temperature: Minimum spawning temperature in nature variously reported, 17–27 C,[9,14,22,24,43,44,62] in laboratory 23.5 C;[9] nest observed at maximum of 35 C.[63]

Notes on spawning and nesting: Older, larger females spawn earlier than younger females;[12,17] yearlings spawn in August;[47] spawning is intermittent during the spawning season,[52] with individual periods of courtship lasting 1–11 days;[56] males guard nest for average of 8.9 days (SD 5.0).[62]

Fecundity: Total counts ca. 2540–64,000, $\bar{x}$ ca. 18,300;[14,22] count for single ovary 11,257;[28,45] fecundity increases with increasing size of female, in 2 year old fish (average length 130 mm), average 3820, in 3 year old fish (average length 148 mm), average 9264, in 4 year old fish (average length 187 mm), average 19,169;[41] at 140-183 mm SL, 7200–38,184.[57] Counts of ripe ova obtained by stripping 26–2592.[8,18]

Number of fry in nest 4670[22,57]–224,900;[28,41] reported averages 17,914,[47] 86,631.[45]

EGGS

Location: Demersal,[10,57] attached to pebbles,[22] small rocks, sticks, leaves[14] or roots.[12]

Unfertilized eggs: Pale yellow, average diameter 1.04 mm, adhesive, a large oil globule at polar end.[9]

Fertilized eggs: Not always round prior to water-hardening;[8] stated size range 1.2–1.4 mm,[2] but average values given as 1.04 mm,[63] 1.15±0.017 mm, 1.23 mm,[56] 1.26 mm,[14] and 1.37±0.020;[56] very early eggs (less than 30 minutes) with blastodisc and oil globule faint yellow; yolk bright yellow-orange;[1,63] color otherwise described as amber;[57] chorion initially soft and pliable, not so after water-hardening,[63] noticeably thick,[8] laminated (JDH); adhesiveness variable[8,14] (although nonadhesive eggs are nonfertilizable[9]) yolk granular; a large single oil globule[14] or one large and many minute oil globules, diameter of oil globule ca. 0.38 mm.[56]

EGG DEVELOPMENT

Development at 22.2–23.3 C.[14]

Immediately after fertilization—Blastodisc constricted at margin forming cap.

35 minutes	First cleavage furrow evident.
55 minutes	Second cleavage furrow.
Ca. 77 minutes	8-cell stage.
1 hour, 20 minutes	16-cell stage or beyond.
1 hour, 40 minutes	Morula.
3 hours	Blastoderm moving down over yolk.
4 hours	Blastoderm to equator.
6 hours	Embryo formed, anterior and posterior ends distinct.
9 hours	Blastoderm nearly covers yolk.
11 hours	Yolk plug still evident, head expanded laterally.
17 hours	10–12 somites; brain, optic invagi-

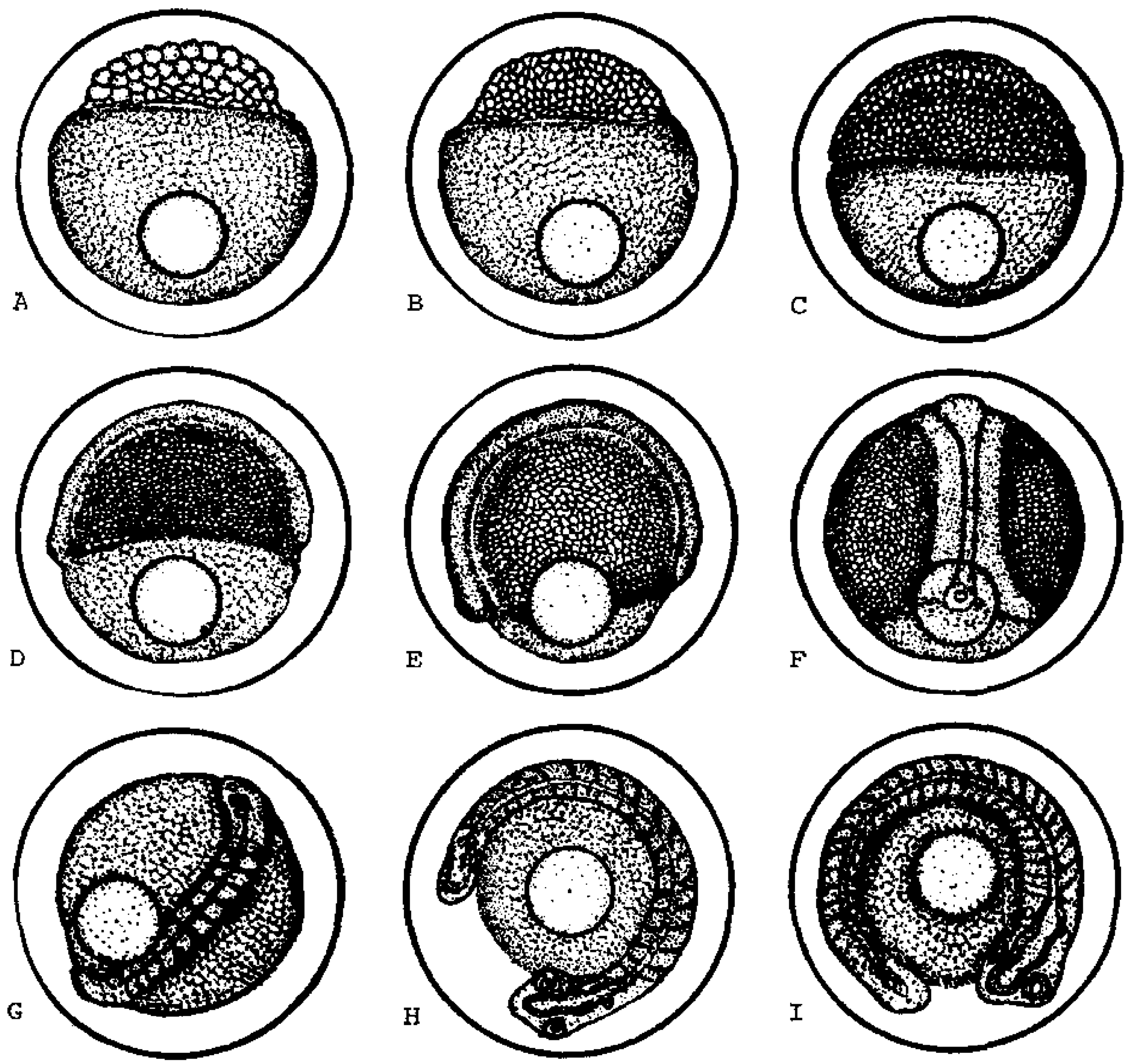

Fig. 127. *Lepomis macrochirus*, Bluegill. A. Early morula, 1 hour, 40 minutes. B. Late morula, 3 hours. C. Blastoderm over one-half of yolk, 4 hours. D. Early embryo, 6 hours. E. Advancing embryo, lateral view, 9 hours. F. Advancing embryo, dorsal view, 11 hours. G. 10–12 somites, 17 hours. H. Tail-free stage, 20–22 somites, 21 hours. I. 25–27 somites, 25 hours. (*A-I, Morgan, G. D., 1951: pl. 1, figs. 6–14.*)

	nations evident; embryo over 2/3rds yolk.
21 hours	20–22 somites, tail free, body movements established, otic capsule present, notochord evident.
25 hours to 26 hours, 30 minutes	25–28 somites, circulation established, no hemoglobin, tail extended to head.
29–30 hours	32 somites, yolk sac reduced.
31 hours, 40 minutes	33–35 somites.
31 hours, 50 minutes	Hatching.[14]

Incubation period:

At 18.5±1 C	75–85 hours.[56]
At 21.1 C	72 hours [2] (but age at start uncertain, JDH).
At 22.2–23.3 C	31 hours, 50 minutes to 62 hours.[3,14]
At average 22.3 C (SD 0.24)	From 69.3 (SD 4.44) to 71.8 (SD 2.87) hours, combined samples (3) 71.1 (SD 3.32) hours.[48,66]

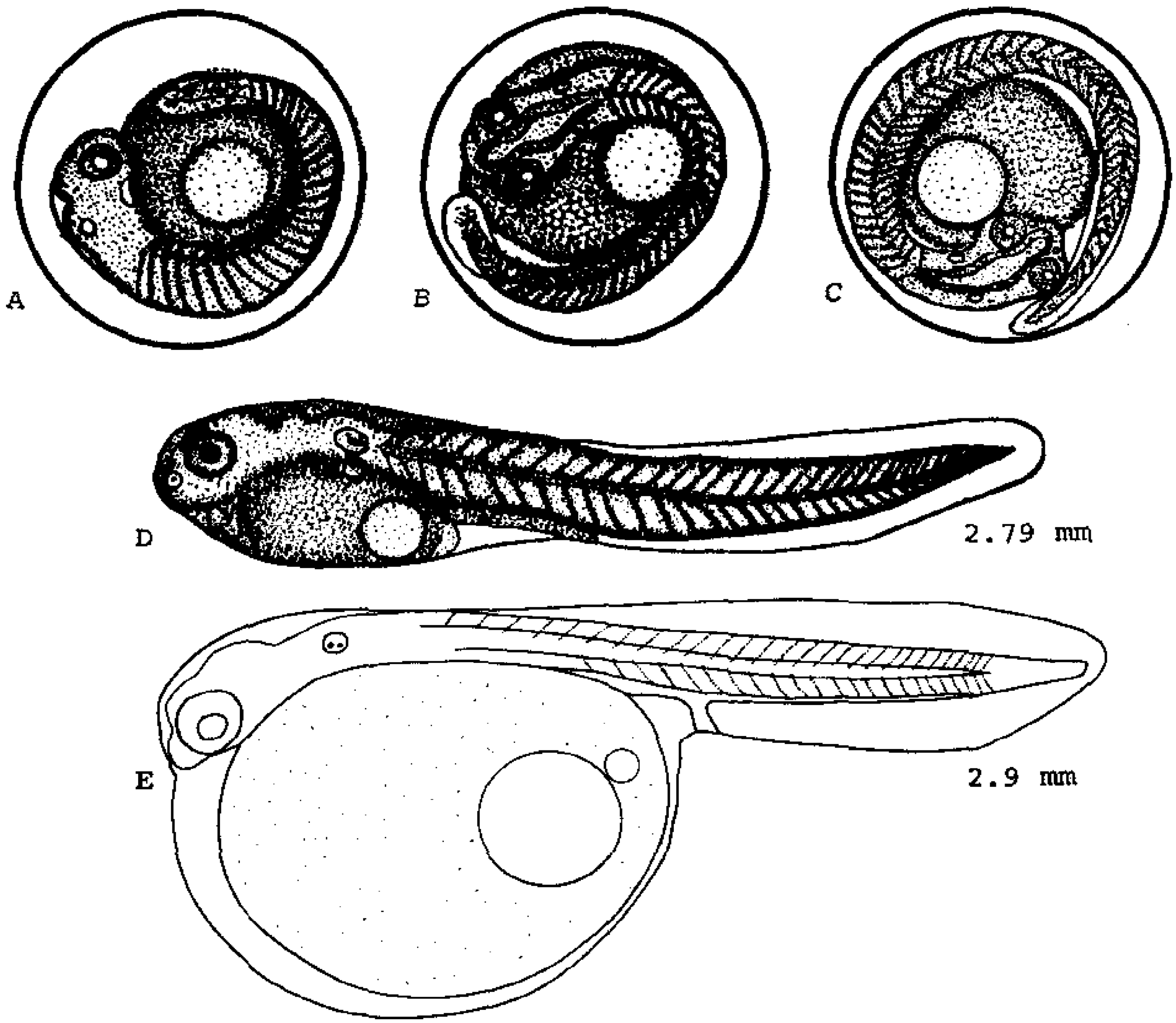

Fig. 128. *Lepomis macrochirus*, Bluegill. A. 28 somites, 26.5 hours. B. 32 somites, 29 hours. C. 33–35 somites, 31 hours, 40 minutes. D. Yolk-sac larva, just hatched (specimen from Ohio), 31 hours, 50 minutes after fertilization, 2.79 mm TL. E. Yolk-sac larva, recently hatched specimen from Maryland), 33.5 hours after fertilization, 2.9 mm TL. (*A-D, Morgan, G. D., 1951: pl. 1, figs. 15–18. E, Carver, D. M., 1976: fig. 2.*)

At average 22.6 C (SD 0.68)	Average 71.1 hours $\pm$3.32.[43]
At 23.5$\pm$0.5 C in constant dark	37–60 hours.[9,63]
At 23.5$\pm$0.5 C in constant light	35–55 hours, average ca. 45 hours.[9,63]
At 24.5 C$\pm$ 1 C	37–43 hours.[56]
At average 26.8 C (SD 0.37)	33.4 (SD 2.11) to 34.2 (SD 2.20) hours, combined samples (3) 33.9 (SD 2.06) hours.[43,66]
At average 26.9 C (SD 0.48)	33.9 hours (SD 2.06).[43]
At average 27.0 C (SD 0.42)	32.3 (SD 0.54) to 32.9 (SD 0.85) hours, combined samples (3) 32.5 (SD 0.83) hours.[43,66]
At average 27.3 C (SD 0.65)	32.5 hours (SD 0.83).[43]
At 28.5 C$\pm$1 C	27–29 hours.[56]

Maximum reported incubation period at unspecified temperature, 5 days (120 hours).[22,57]

Notes on incubation: At 18.5 C, 46% abnormal larvae, although this temperature is considered near optimum spawning temperature.[56]

TABLE I. Comparative development at various temperatures (data from Nakamura, *et al.*)[56]

Time	Water temperatures 28.5±1.0 C	24.5±1.0 C	18.5±1.0 C
1 hour	4-cell stage	2-cell stage	Blastodisc formed
2 hours	Morula stage	Many cell stage—morula stage	4- to 8-cell stage
5 hours and 20 minutes	Middle gastrula	Later blastula stage—early gastrula stage	Early morula stage
10 hours and 20 minutes	3-somite stage	Later gastrula stage—early embryo evident	Later blastula stage—early gastrula stage
18 hours and 20 minutes	27- to 28-somite stage	18- to 19-myotome stage, otoliths evident	Early embryo evident
29 hours and 10 minutes	Hatching	Embryo completely encircles the yolk	4-somite stage
41 hours and 20 minutes		Hatching	18- to 19-myotome stage
85 hours			Hatching

YOLK-SAC LARVAE

Minimum length at hatching 2.2–3.23 mm; [14,56,69] length at end of stage ca. 5.0–6.0 mm [64] (specimens up to 5.84 mm long and 9 days old lack yolk but retain the oil globule); critical period (50% mortality from starvation) estimated as 4.4 days after hatching, 6.4–9.0 days after fertilization.[9,63]

Myomeres 23 [8]–35,[69] 10+21 (derived from figure).[1]

At 2.79 mm (newly hatched) snout-vent length 1.53 mm, depth 0.63 mm, HL 0.63 mm, eye diameter 0.13 mm; at 3.51 mm (16 hours) snout-vent length 1.69 mm, eye diameter 0.22 mm; at 3.96 (2 days, 4 hours) snout-vent length 1.98 mm, eye 0.37 mm.[14] At hatching (3.23 mm TL) yolk 1.13×0.9 mm.[56]

Anus initially beyond midpoint of TL; by 4.5 mm conspicuously anterior to midpoint.[8] At 4.99–5.81 mm (200 hours) head relatively large, trunk narrow; jaws developed but mouth not open at 4.27–5.54 mm (97 hours); jaws movable, mouth open at 4.64–4.82 (129 hours); [9] operculum formed at 4.75 mm (6 days, 9 hours); [14] otoliths evident at 2.9 mm.[8] At 3.3–3.7 mm (56 hours) yolk lemon-shaped; at 3.48–4.40 mm (73.5 hours) yolk conspicuously granular; [9] at 4.75 mm yolk greatly reduced; [14] at 4.92–5.84 mm yolk gone, oil globule still evident.[9] Oil globule initially in upper posterior region of yolk, somewhat more forward by end of stage.[8] Mesenchyme evident in dorsal and anal fins at 4.75 mm; [14] pectoral buds evident at 3.26–3.72 mm (56 hours); incipient rays in caudal and pectorals at 4.27–5.54 mm (97 hours); pelvics developing at 4.92–5.84 mm (217 hours).[9] Anus clearly open at 3.48–4.40 mm (73.5 hours); alimentary canal open from mouth to anus, peristalisis established at 4.27–5.54 mm (97 hours); [9] heart with distinct sigmoid curve at 4.5 mm; gas bladder first evident at 3.0 [8]–4.64 mm; [9] assumed yolk-sac larva (prolarva, size not stated) with open pneumatic duct and well-developed *rete mirabile*.[19]

Pigmentation: At hatching entirely without pigment; pigment first evident in eye at minimum lengths of 3.5 [14]–3.9.[8] In specimens from Indiana 4.58–5.21 mm long (148 hours old) eyes pigmented, a prominent pigment spot on each side of body dorsal to anus; [9,63] in a similar-sized specimen from Ohio (4.54 mm) chromatophores in dorsal and ventral body walls; [3] in a specimen from Maryland 4.5 mm long and 148 hours old, a prominent row of melanophores ventrally posterior to anus; in an identically sized Maryland specimen 168 hours old several melanophores along mid-lateral line, and a prominent pigment blotch over gut near anus in addition to ventral pigment row.[8] In a series of specimens from Indiana: at 4.99–5.81 mm (200 hours) pairs of pigment spots lateral and dorsal to anus, along abdomen, and posterior to liver; at 4.92–5.84 mm (217 hours) gas bladder black; at 5.41–5.80 mm some orange pigment in eye.[9,63] In a 5.4 mm specimen from Oklahoma, pigment restricted to dorsal surface of gas bladder, and a faint row of pigment ventrally between anus and tail.[1]

LARVAE

Size range 5.04 [14] to ca. 13.0 mm; [56] minimum age at beginning of stage 8 days; [14] length at swim-up 4.8–5.7 mm.[69]

At 5.04 mm, snout-vent length 2.11 mm, eye diameter 0.32 mm.[14]

Preanal finfold still conspicuous at 10.5 mm.[1] Anlagen of dorsal and anal fins sometimes not evident until 6.0 [13]–7.7 mm [1] (although in other cases evident in smaller yolk-sac larvae, JDH); dorsal and anal rays evident at 10.5 mm, dorsal spines at 12.0 mm; [1] incipient caudal rays at 7.0–7.2 mm; [2] pectorals rayless at 10.5 mm, with rays at 12.0 mm; ventrals developing at 10.5 mm.[1] (Formation of pectoral and caudal rays prior to beginning of larval stage [9] is questioned, JDH). Notochord flexed at 10.5 mm.[1]

Pigmentation: At 5.4–5.63 mm (Indiana series) ca. 11 pigment spots ventrally between anus and tail, 2–3 lateral and dorsal to anus, and 3–4 ventrally between heart and anus; gas bladder heavily pigmented.[9] At 5.5 mm (California series) top of head unpigmented.[2] At 6.8 mm (Oklahoma series) ventral pigment posterior to anus in more or less discrete row.[1] At ca. 7.0 mm (California) a row of chromatophores along posterior margin of head.[2] At 7.7–12.0 mm (Oklahoma) a faint suggestion of mid-lateral pigment, pigment lacking on head.[1] At 9.0 mm (California) head entirely pigmented, chromatophores developed in egg-shaped pattern on isthmus. At 10.3 mm (California) pigment concentrated on sides and top of head, a row of distinct mid-lateral spots, ventral pigment row well-developed and passing to each side of anal

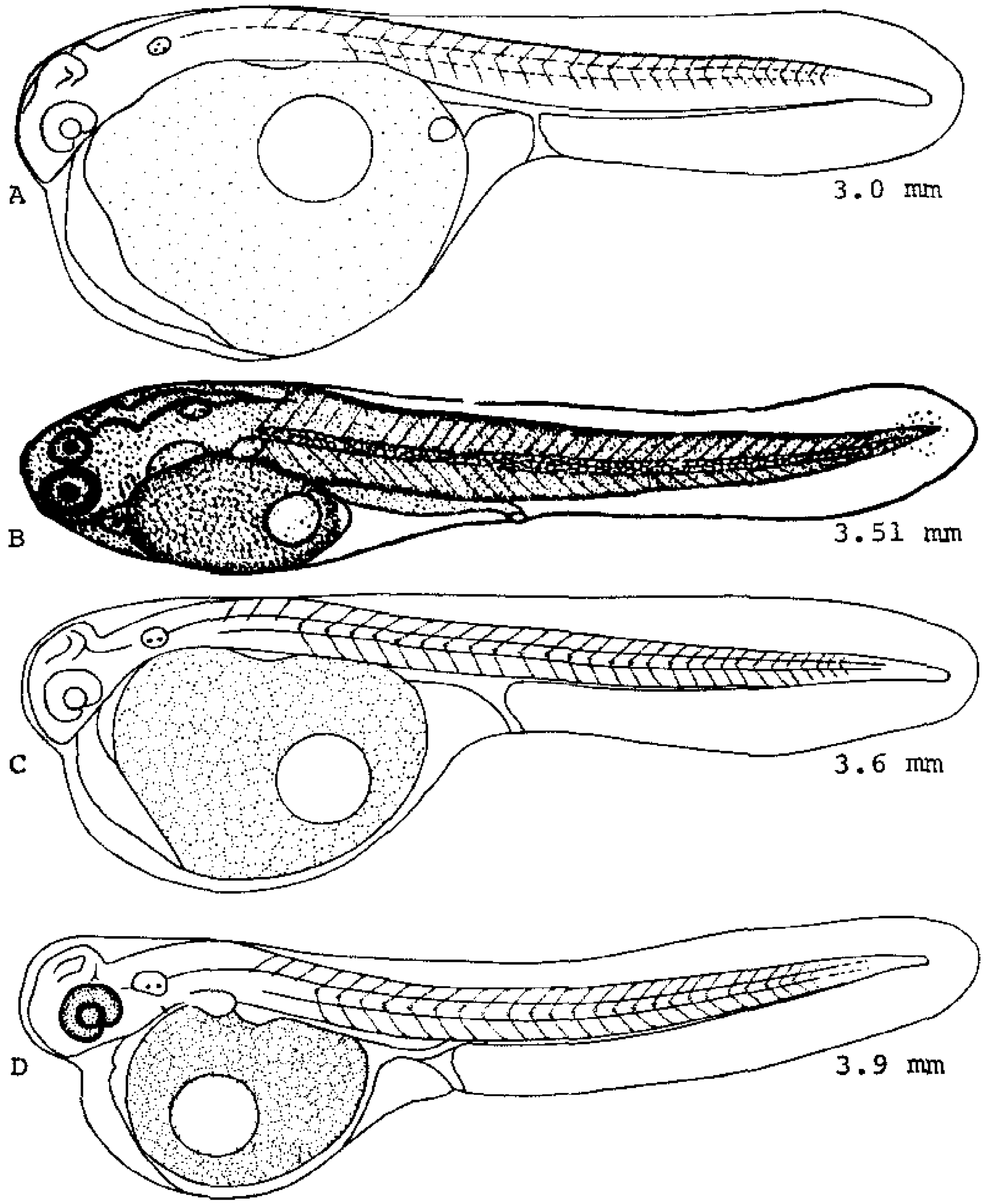

Fig. 129. *Lepomis macrochirus*, Bluegill. A. Yolk-sac larva, 3.0 mm. B. Yolk-sac larva, 3.51 mm. C. Yolk-sac larva, 3.6 mm. D. Yolk-sac larva, pectoral buds evident, 3.9 mm. A, C, D, specimens from Maryland; B, specimen from Ohio. (*A, C, D, Carver, D. M., 1976: figs. 3–5. B, Morgan, G. D., 1951: pl. 2, fig. 1.*)

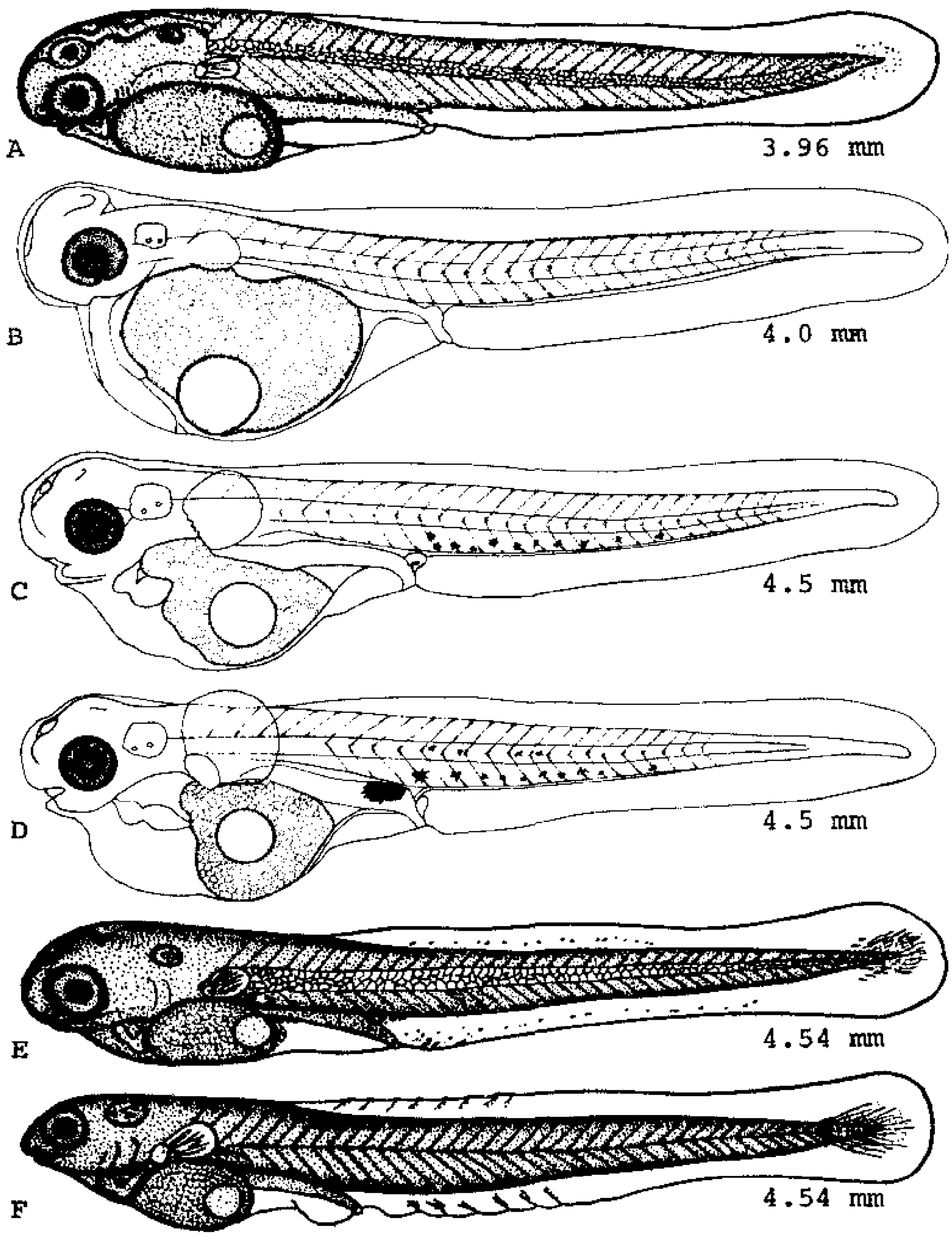

Fig. 180. *Lepomis macrochirus*, Bluegill. A. Yolk-sac larva, 3.96 mm. B. Yolk-sac larva, 4.0 mm. C. Yolk-sac larva, 4.5 mm, pigment clearly developed ventrally. D. Yolk-sac larva, 4.5 mm (note prominent pigment patch over posterior end of gut, and mid-lateral line of melanophores). E. Yolk-sac larva, 4.54 mm, 3 1/2 days after hatching. F. Yolk-sac larva, 4.54 mm, 4 1/2 days after hatching. A, E, F, specimens from Ohio; B, C, D, specimens from Maryland. (*A, E, F, Morgan, G. D., 1951: pl. 2, figs. 2, 3, 4. B, C, D, Carver, D. M., 1976: figs. 6–8.*)

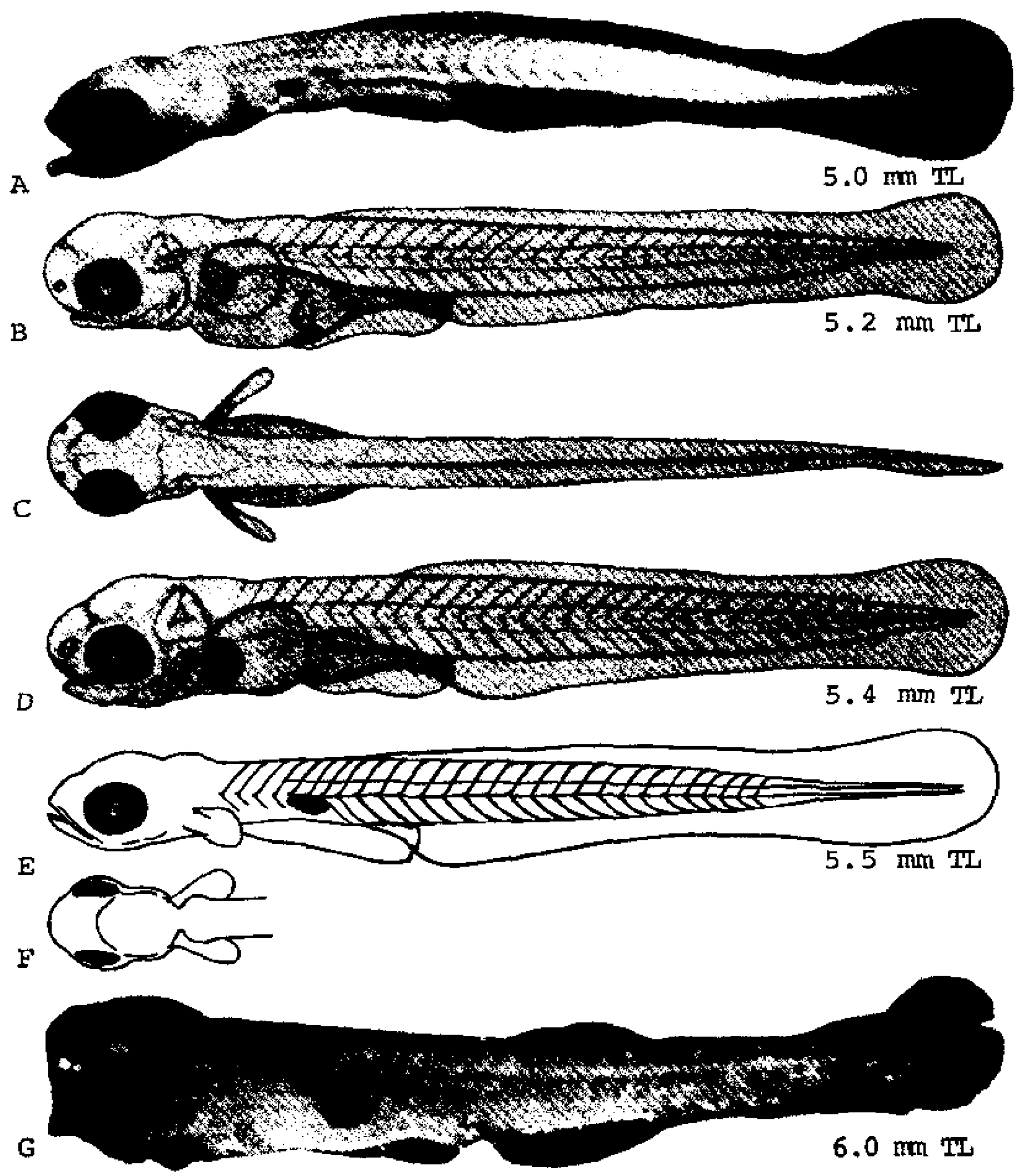

Fig. 131. *Lepomis macrochirus*, Bluegill. A. Yolk-sac larva (or larva), 5.0 mm, gas bladder pigmented. B. Yolk-sac larva, 5.2 mm. C. Same as B, dorsal view. D. Yolk-sac larva, 5.4 mm, pigment over gas bladder, and in faint row ventrally beyond anus. E. Larva, 5.5 mm (note long preanal finfold). F. Same as E, dorsal view of head. G. Larva, 6.0 mm (note advanced development of caudal fin and reduction of finfold). A-D, G, specimens from Oklahoma; E, F, specimens from California. (*A, G, May, E. B., and C. R. Gasaway, 1967: figs. 35, 36. B, C, D. Taber, C. A., 1969: figs. 14A, A_1, B. E, F, Meyer, F. A., 1970: fig. 3.*)

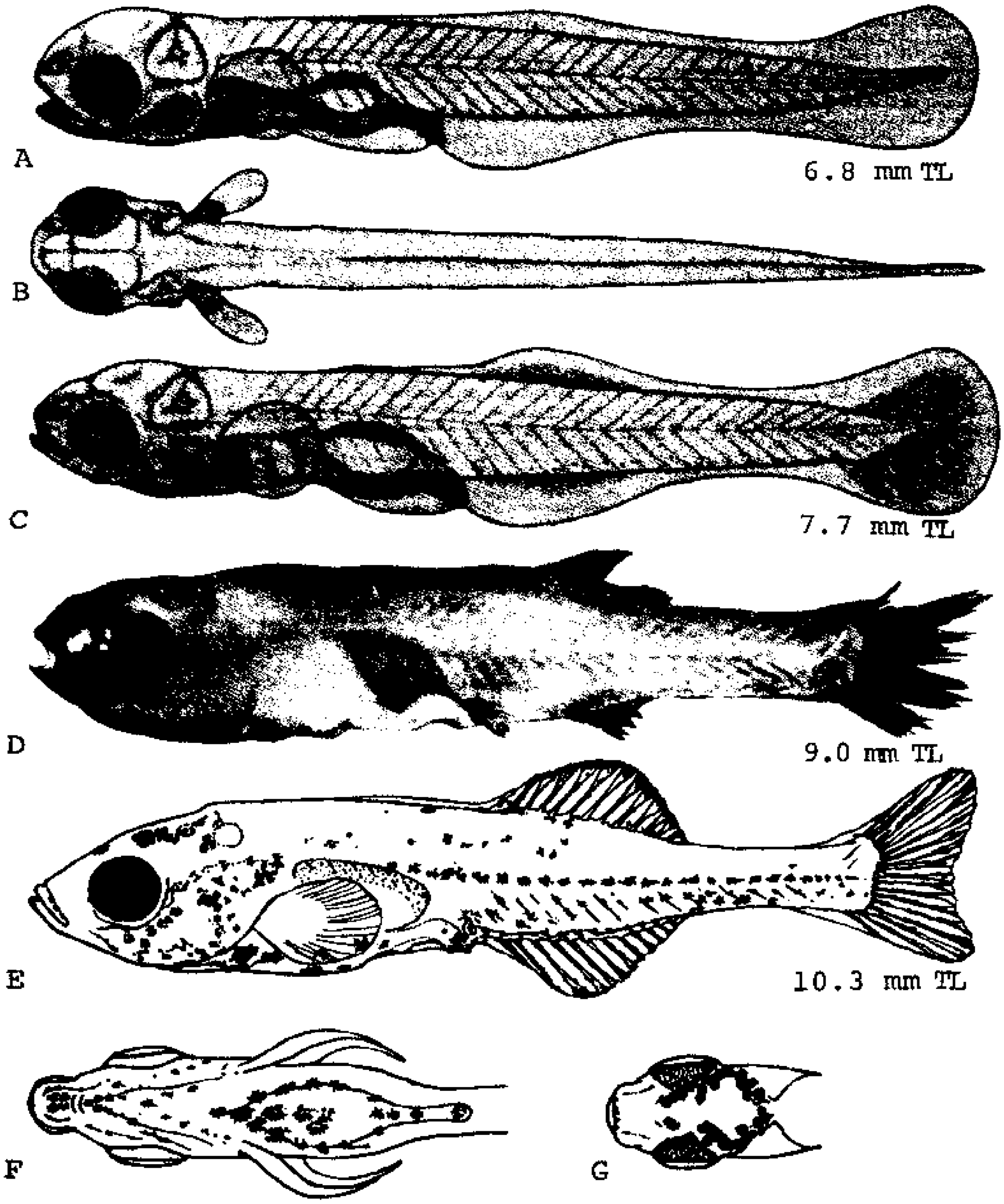

Fig. 132. *Lepomis macrochirus*, Bluegill. A. Larva, 6.8 mm. B. Same as A, dorsal view. C. Larva, 7.7 mm (note that, in this specimen, the fins are just beginning to develop). D. Larva, 9.0 mm, urostyle flexed. E. Larva, 10.3 mm. F. Ventral view of E. G. Dorsal view of E. A-D, specimens from Oklahoma; E-G, specimens from California. (*A, B, C, Taber, C. A., 1969: fig. 14, C, C_1, D. D, May, E. B., and C. R. Gasaway, 1967: fig. 37. E, F, G, Meyer, F. A., 1970: fig. 3.*)

fin.[2] At 10.5 mm (Oklahoma) ventral pigment row diffuse, faint pigment on caudal fin.[1] At 11.1 mm (California) pigment no longer evident on isthmus.[2] At 12.0 mm (Oklahoma) ventral pigment spreading laterally, pigment over gas bladder less conspicuous.[1]

JUVENILES

Minimum size described, ca. 12.0–13.0 mm.[56,64]

At 12.0–21.0 mm average precaudal vertebrae 12.0, average caudal vertebrae 16.94–17.00. Number of ribs increases with increasing size; at 12.0 mm, 7, at 21.0 mm, 9.[64]

At 14.5 mm (age 3–4 weeks), snout-vent length, 6.5 mm, greatest depth 2.75 mm, eye diameter 1.2 mm.[14] At 12.0–17.0 mm mean ratio body depth to TL 4:6.[64]

In some specimens scales first evident at 17.0 mm SL;[4] in others fully formed at 14.0–15.0 mm TL.[56] At 14.0 mm gas bladder well-developed, devoid, by atrophy, of pneumatic duct; vestigial *rete mirabile* evident.[19]

Pigmentation: At 13.5 mm (Oklahoma series) a small faint pigment patch on head and a similar patch on opercle between eye and pectoral base; pigment developed along mid-lateral line on posterior third of body; scattered chromatophores ventrally from anal origin to tail, these extending up to almost mid-lateral line; chromatophores evident on caudal and anal fin.[1] At 14.0–15.0 mm (Japan) "lateral stripe pattern" evident.[56] At 14.5 mm (Oklahoma) pigment on head, opercles, jaws, fins, and body.[14] At 15.0 mm (Indiana) a line of melanophores on ventral side, but this interrupted and not present on belly; melanophores on breast dispersed.[64] At 21.5 mm (Oklahoma) pigment evident in all fins except ventrals, ca. 11 narrow pigment bands on body between head and end of caudal peduncle, these extending to ventral line only on peduncle.[1] At *ca. 19.0–38.0 mm 10 or more vertical bars on sides.*[36] At "less than ca. 50 mm" a few large melanophores on breast (useful in separating *macrochirus* juveniles from those of *gibbosus*).[7] "Immature specimens" with light flesh-colored breast like females, but blue-green body pigment and vertical bars more pronounced.[22] Young lighter than adults, usually silvery, sometimes with purplish

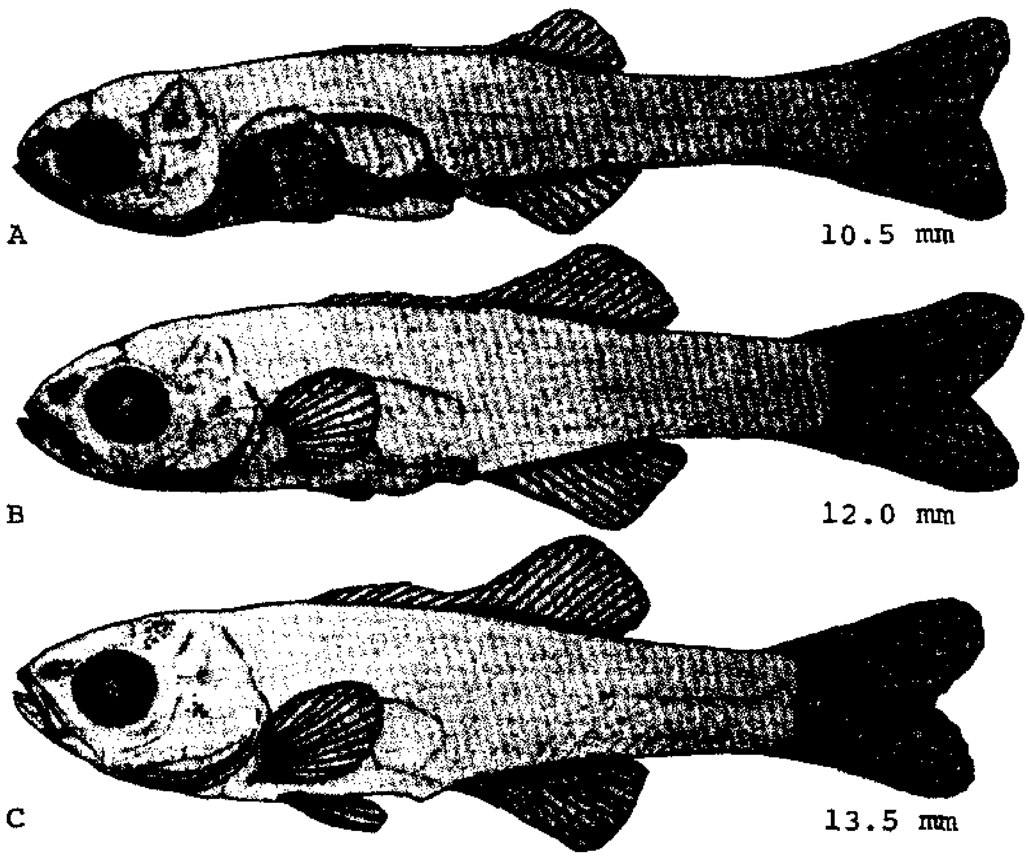

Fig. 133. *Lepomis macrochirus*, Bluegill. A. Larva, 10.5 mm, ventral buds evident. B. Larva, 12.0 mm, dorsal spines forming. C. Juvenile, 13.5 mm. All specimens from Oklahoma. (*A-C, Taber, C. A., 1969: fig. 14, E-G.*)

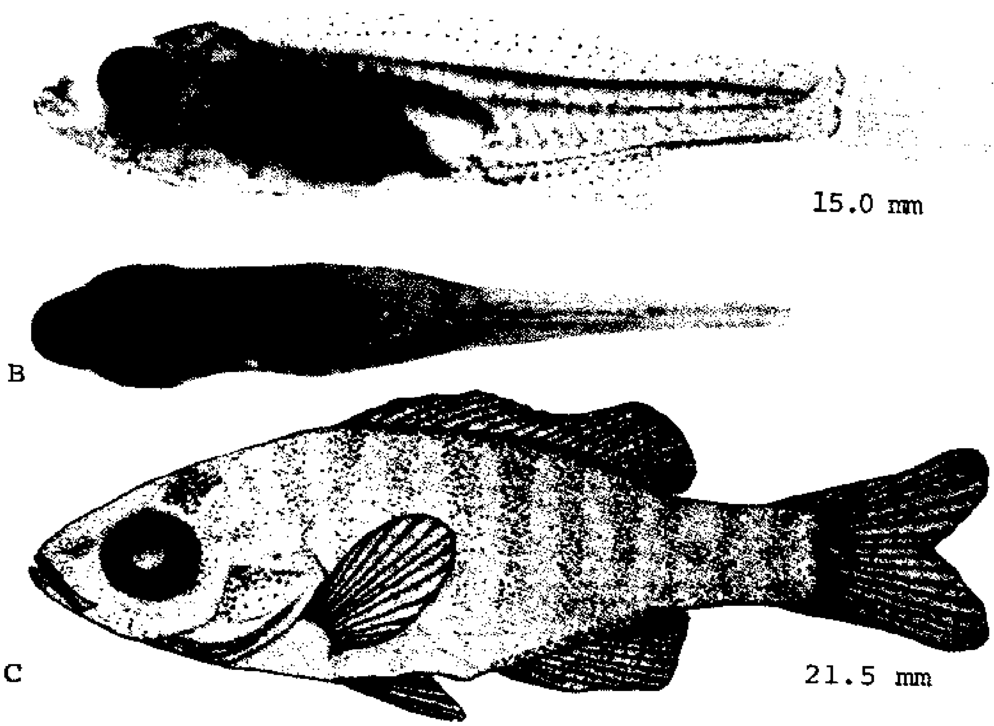

Fig. 184. *Lepomis macrochirus*, Bluegill. A. Juvenile, 15.0 mm. B. Same as A, ventral view showing characteristic pigment pattern. C. Juvenile, 21.5 mm. A, B, specimen from Indiana; C, specimen from Oklahoma. (*A, B, Werner, R. G., 1966: figs. 4, 5. C, Taber, C. A., 1969: fig. 14, H.*)

sheen, spot on soft dorsal indistinct or absent,[27,49] no blue streaks on lower sides of head.[7] Yearlings and 2 year olds (thus, in some parts of range, including recently mature individuals) grayish blue on back and sides, with indistinct lateral barring and solid black opercular spot.[62]

AGE AND SIZE AT MATURITY

Minimum reported age at maturity, ca. 4 months (at weight of 28–56 g);[36,52] otherwise minimum age at maturity at end of 2nd summer when 1 year old,[3,32] or, in Canada, males at 2–3 years, females at 3–4 years.[57] Minimum length at maturity, 75–100 m.[3,7,15,22,44]

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Lepomis megalotis (Rafinesque), Longear sunfish

ADULTS

D. X to XI, 10–12 [19] A. III, 8 [10]–12; [19] P. 13–15; [11] V. I, 5; [21] scales in lateral line 33 [11]–45 [10] (33–38 in *L. megalotis peltastes*, 39–44 in *L. m. megalotis* [14]), in transverse series 5/14,[10] on cheek 5–7,[11] vertebrae 28–30; [24] gill rakers on lower limb of first arch variously reported as 8–9; [17] and 12; [10] 5 on upper limb; branchiostegals 6–7; pyloric caeca 7.[24]

Body short, deep, strongly compressed; [10] mouth small; [11] gape usually to, or just past, anterior edge of eye,[24] some-

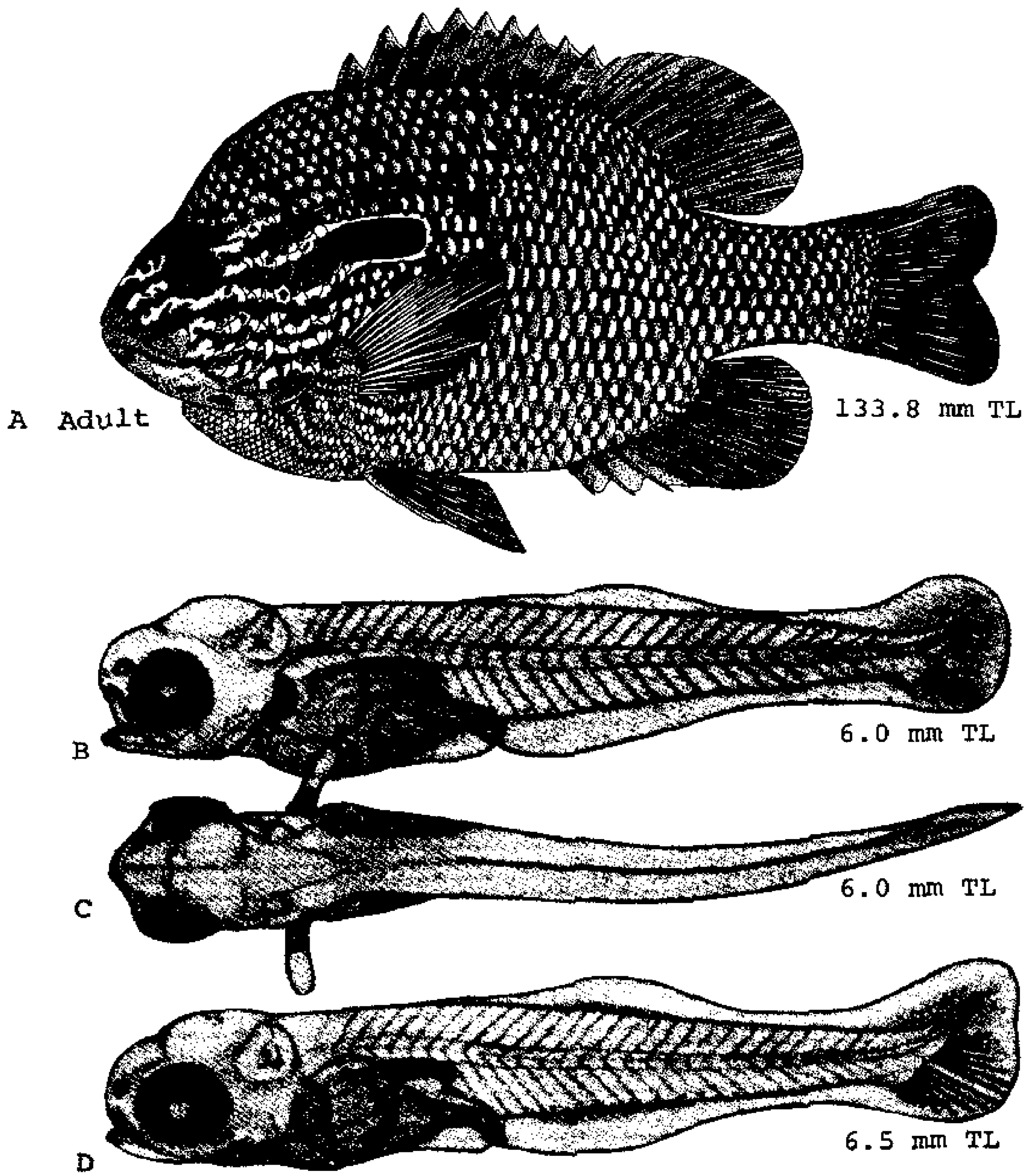

Fig. 135. *Lepomis megalotis*, Longear sunfish. A. Adult, 133.8 mm TL. B. Larva, 6.0 mm TL. C. Dorsal view of B. D. Larva, 6.5 mm TL, urostyle oblique. (*A, Trautman, M. B., 1957: fig. 136. B-D, Taber, C. A., 1969: fig. 15, A, A₁, B.*)

times extended to middle of eye. Tongue without teeth.[21] Gill rakers short, knobby.[12]

Pigmentation: Dorsum bluish,[17] dark brown with bluish sheen,[10] or olive green with specks of yellow, emerald, and green;[8] in one population from Oklahoma a median brick-red stripe from origin of dorsal fin to about level of eyes.[4] Sides olive green (but lighter than back)[8] to dark blue-violet[10] and with intense spotting of emerald, blue,[8] greenish, or reddish yellow dots and with 7[10] to 12 faint transverse bands (although these absent in some specimens).[8] Cheeks orange with blue stripes;[17] sides of head with much emerald-blue and several wavy light orange or orange-red bars radiating backward from mouth to eye,[8] lips blue[18] or green. Opercular flap variously described: blue-black edged with golden green;[10] with or without bluish margin;[12] with pale blue or red margin;[17] and with black opercular spot bordered with white, this sometimes flushed with red and with 1–9 small orange or red spots.[8] Eye blood red or blackish red.[10] Venter yellow,[8] greenish yellow,[10] orange,[17] or orange-red. Dorsal and anal described as olive slate, deep rusty orange (in breeding males),[8] greenish with white border,[10] or with rays blue and membranes yellow.[17] Caudal bluish, rusty orange,[8] or greenish with white border.[10] Pelvics blue-black in breeding males.[8] Breeding males more brilliantly colored[15] and males consistently more brilliant than females. In females, reds replaced by orange or pale white and with greater tendency toward lateral banding and spots on fins. In the subspecies *peltastes* lateral bands usually present, often sharply outlined; soft dorsal and anal fin vaguely spotted; margin of opercle with only one rather large red spot.[8]

Maximum length: 236.2 mm.[8]

DISTRIBUTION AND ECOLOGY

Range: From Minnesota east to Ontario and southern Quebec, Ohio, and western Pennsylvania; south, through Mississippi basin to Gulf states and Mexican tributaries of Rio Grande;[11,12,13] north on Atlantic coast to North Carolina.[17] Presumably introduced in Chesapeake Bay area (JDH).

Area distribution: Recorded from Potomac River estuary by Anjard.[8]

Habitat and movements: Adults—creeks and smaller rivers, rarely in large rivers;[1] in long sluggish pools in clear sections of low gradient streams; also in clear water lakes and ponds; prefer bottoms of sand and gravel, and frequently found in beds of aquatic vegetation.[8,9] Occupy home ranges of approximately 21 m in streams.[6] Recorded in water with surface salinity of 5.0 ppt, bottom salinity of 11.8 ppt.[5]

Larvae—yolk-sac larvae at bottom; larvae most abundant at bottom, although some swim upward and disperse at night.[2]

Juveniles—at bottom in shallow water;[2] maximum salinity, "subadults" at 0.2 ppt.[16]

SPAWNING

Location: Inshore[22] at depths of 13–81 cm ($\bar{x}$=35.5 cm)[7] in lakes and near mouths of rivers entering lakes;[1] also in both calm[2] and running water[4] in creeks[2] and streams[1] over bottoms of rock, sand,[2] gravel, or marl.[7]

Nests: Nests may be more or less isolated from one another or crowded together in small colonies;[7,15,22] Hankinson reported groups of 5–13 nests as close together as 2.5–30 cm.[23] The nests, themselves, are circular or slightly ovoid depressions up to 46 cm in diameter and 5 cm deep.[6,20,22]

Season: In Oklahoma mid-May to mid-August;[2] in Potomac River early May through August;[19] in Michigan late June to August.[3,20]

Temperature: Minimum 20 C, optimum 23–25 C.[19]

Fecundity: 2360–22,119.[24]

EGGS

Location: Demersal,[24] attached to stones[1] and roots.[3,2]

Fertilized eggs: Diameter 1.0 mm,[19] amber to pale yellow.[24]

EGG DEVELOPMENT

Incubation: 3–5 days at unspecified temperature.[24]

YOLK-SAC LARVAE

Assumed hatching length, 2.5–3.0 mm,[19] length at end of stage uncertain.

Yolk-sac larvae undescribed except for comment that incipient caudal rays develop in "prolarvae."[2]

LARVAE

Size range described, 6.0–11.3 mm.

Myomeres, at 6.0–7.1 mm, 10–12 + 17–18[2] (based on counts from illustrations, JDH).

Proportions as times in TL: Depth at 6.0 mm ca. 5, at 6.5 mm ca. 5.5, at 11.3 mm ca. 4.2[2] (derived from illustrations, JDH).

Nostrils barely divided, choroid fissure still evident at 11.3 mm.[2]

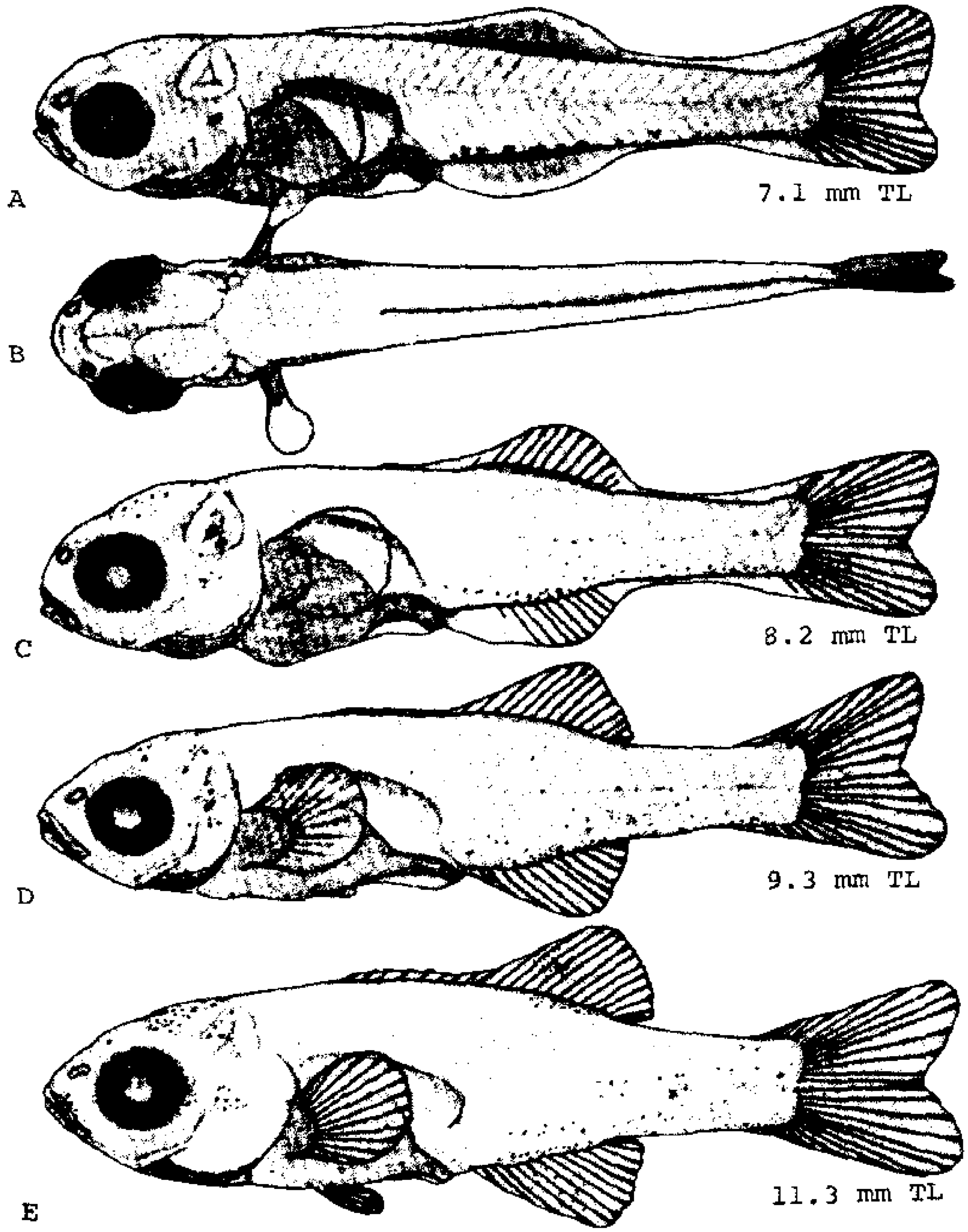

Fig. 136. *Lepomis megalotis*, Longear sunfish. A. Larva, 7.1 mm TL. B. Dorsal view of A. C. Larva, 8.2 mm TL. D. Larva, 9.3 mm TL. E. Larva, 11.3 mm TL. *(A-E, Taber, C. A., 1969: fig. 15C-F.)*

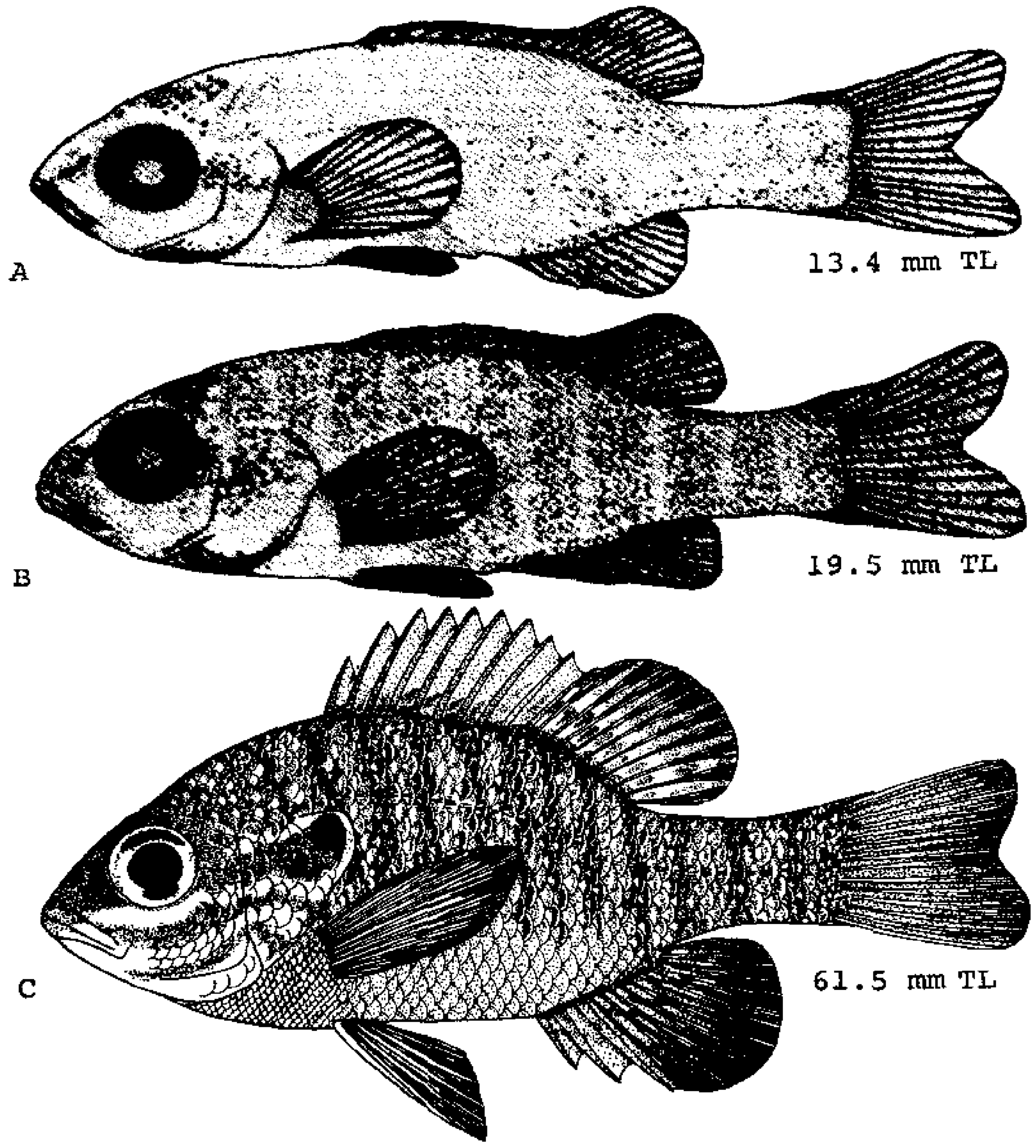

Fig. 137. *Lepomis megalotis,* Longear sunfish. A. Juvenile, 13.4 mm TL. B. Juvenile, 19.5 mm TL, barred pattern developing. C. Juvenile, 61.5 mm TL. (*A, B, Taber, C. A., 1969: fig. 15, G, H. C, Trautman, M. B., 1957: fig. 136.*)

Mesenchyme evident in dorsal and anal fins at 7.1 mm, rays at 8.2 mm. Dorsal spines developing at 9.2 mm. At 6.0 mm caudal fin with several definite rays; caudal fin emarginate at 7.1 mm. Pectoral fins well-developed, rounded at 6.0 mm; rayless at 8.2 mm, rayed at 9.3 mm. Pelvic buds first evident at 9.3 mm, with well-developed rays at 11.3 mm. Urostyle barely flexed at 6.0 mm, flexion complete at 8.2 mm.[2]

Pigmentation: At 6.0 mm eyes apparently not as well pigmented as in later stages; pigment on dorsal surface of gas bladder; a row of chromatophores, ca. 1 on each myomere, ventrally between anus and tail. At 6.5 mm ventral pigment increased, few pigment spots mid-laterally, and on head and abdomen. At 7.1 mm ventral pigment spots apparently consolidated on myomeres, particularly above anal fin; pigment developed on gut just before anus; a faint pigment blotch on upper part of opercle. At 8.2–9.3 mm body and head pigment somewhat increased; pigment on gas bladder less evident than in earlier stages; pigment on gut no longer evident; chromatophores developed in basal portion of caudal fin. At 11.3 mm additional pigment developed in soft dorsal and anal fins and on upper jaw.[2]

JUVENILES

Size range described, 13.4 [2] to slightly longer than 50 mm.[10]

At 17–30 mm average pectoral rays 12.19, average precaudal vertebrae 12.03, average caudal vertebrae 17.93, average ribs 10.31.[2]

Depth ca. 4 times in TL [2] (derived from drawings, JDH). Opercular flap much shorter in "young" than in adults.[18]

Pigmentation: At 13.4 mm scattered pigment over posterior part of body; a prominent pigment patch behind eye; pigment developed in spinous dorsal. At 19.0 mm pigment dense in all fins except pelvics; ca. 10 pigment bands, wider than interspaces, between head and tail, those from anal origin to end of caudal peduncle reaching ventral margin.[2] In two specimens slightly longer than 50 mm lateral bands still prominent, a number of conspicuous dark spots dorsally along base of dorsal fin; head and opercle with light markings.[10] "Young" described as similar to female except lack orange and blue pigment, their lateral bands usually prominent.[8]

AGE AND SIZE AT MATURITY

Mature at 2–4 years; [24] males mature at ca. 100 mm, females ca. 75 mm,[1,6] but in stunted populations 60 mm,[5] and in the subspecies *L. megalotis peltastes* 53.3 mm.[8]

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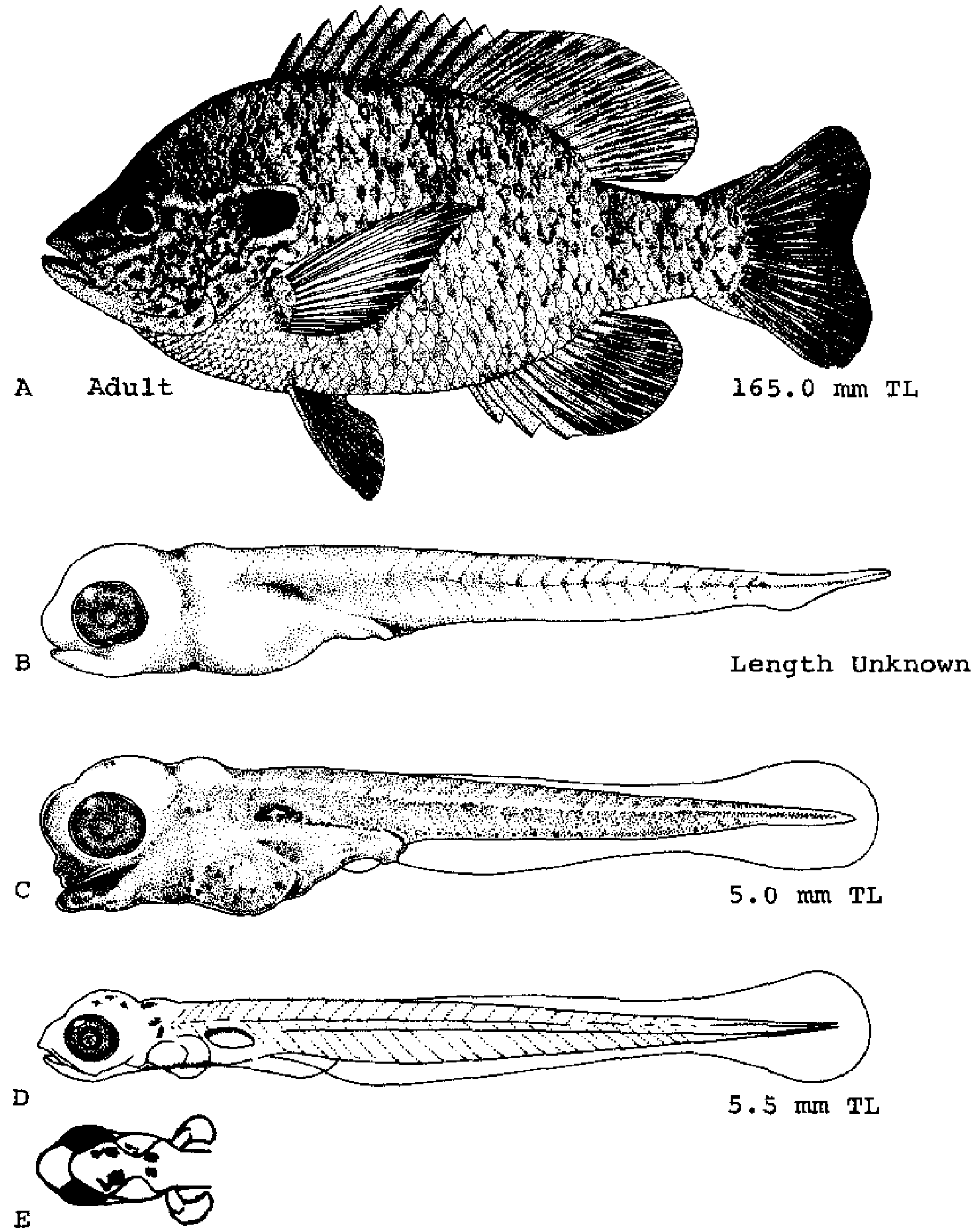

Fig. 138. Lepomis microlophus, Redear sunfish. A. Adult, 165.0 mm TL. B. Yolk-sac larva, length unknown. C. Yolk-sac larva, 5.0 mm TL, ventral pigment developed. D. Larva, 5.5 mm TL. E. Dorsal view of head of D. (*A, Trautman, M. B., 1957: fig. 138. B, C, Redrawn from Childers, W. F., 1967: fig. 1, Elizabeth Ray Peters, delineator. D, Redrawn from Meyers, F. A., 1970: fig. 4, Elizabeth Ray Peters, delineator. E, Meyers, F. A., 1970: fig. 4.*)

Lepomis microlophus (Günther), Redear sunfish

ADULTS

D. X, 10–12 [24] (mean number of spines 9.97, mean number of rays 11.32 [6]); A. III, 9–11 [24] (mean number of rays 10.51); mean number of pectoral rays 13.74; [6] scales in lateral line 44–45 [24] (mean 44.45), above lateral line average 6.51, below lateral line mean 14.95, on cheek 5; mean gill rakers 9.2.[6]

Pectoral fins 2.7–3.0 times in TL [12] (more than 1/3 SL [15]).

Opercular flap flexible; [16] posterior edge of upper jaw almost to or at anterior edge of eye; no teeth on tongue; gill rakers on first arch, short, blunt, often crooked.[18]

Pigmentation: Olive green above, speckled with darker; sides lighter and with brassy reflections; some males with 5–10 faint vertical bands of dark dusky olive; breast and belly brassy,[2] yellow, or orange; [14] sides of head light bluish brown or slate olive, spotted and mottled with darker; opercular spot black-bordered above, light-bordered below, and posteriorly with a large blood red or orange-red blotch; [2] pelvic fins dusky yellow; [18] other fins light greenish olive and without definite spots; basal half of caudal fin olive slate. In breeding males pelvic fins dusky, breast brighter, entire body more brassy and with intense green and blue reflections.[2]

Maximum length: 263 mm.[2]

DISTRIBUTION AND ECOLOGY

Range: Mississippi drainage from Missouri, Iowa, and Indiana south to Gulf states; on Gulf coast from Rio Grande to Florida; north on Atlantic coast to Georgia.[12,15] Introduced in Oklahoma,[9] New Mexico, California,[7,23] Maryland,[22] and Puerto Rico.[8]

Area distribution: Introduced in Maryland,[22] and apparently established in Potomac River (FJS).

Habitat and movements: Adults—primarily a fish of open waters found in large rivers, springs, lakes,[17] ponds,[15] lagoons,[5] and bayous [15] over bottoms of rock, sand, and muck; [19] associated with aquatic vegetation, and frequently congregate around brush, stumps, and logs.[2] Maximum salinity 12.3 ppt (specimens recorded from water having a bottom salinity of 23.5–25.2 ppt may have been dragged there in a trawl).[4] Temperature range, 20–34 C.[11]

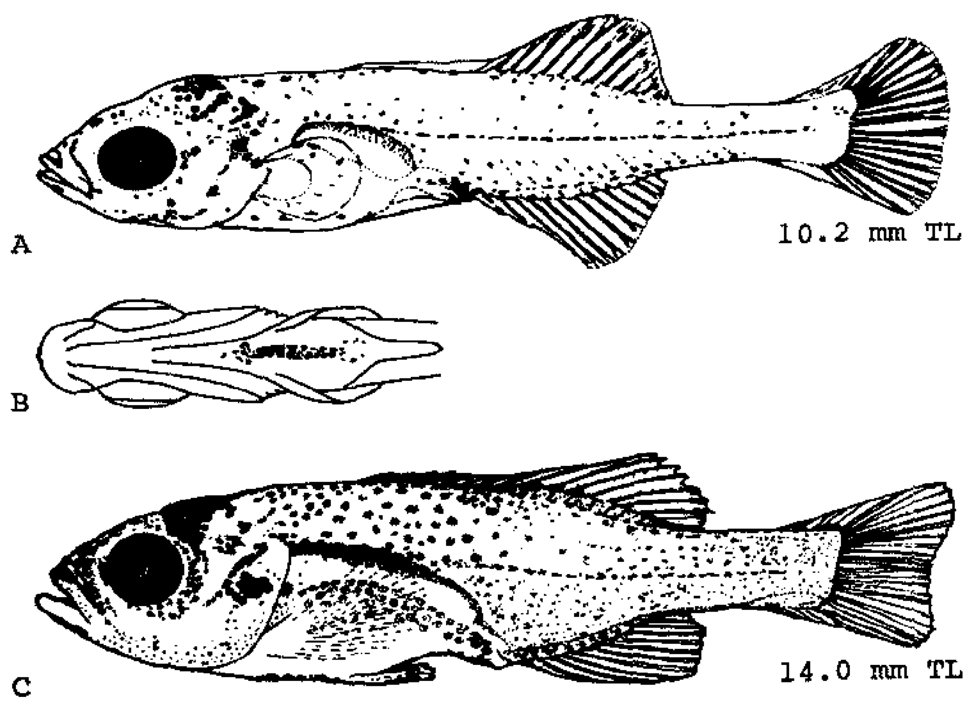

Fig. 189. *Lepomis microlophus*, Redear sunfish. A. Larva, 10.2 mm TL (note retention of predorsal finfold). B. Ventral view of figure A to show thoracic pigment. C. Larva, 14.0 mm TL. (*A-C, Meyer, F. A., 1970: fig. 4.*)

Larvae—no information.

Juveniles—most frequently in vegetated shallow water;[17] mostly along shore, typically at depth of one meter.[18]

SPAWNING

Location: On firm substrate[18] in water ca. 225 mm[10] to 3 m deep.[26] Although Swingle and Smith commented that depths of over 1.8 m are preferred,[28] Gerald reported nests at an average depth of 483 mm.[10]

Nests: Sometimes nest in colonies of up to several hundred, sometimes single; frequently nest is only a depression in vegetation and relatively indistinct.[10]

Season: Spawns in Puerto Rico in February and March;[8] in Texas, April 20 to end of July;[5] in Alabama, in spring, sparingly or not at all in summer, and again heavily in early fall;[18,21] in Florida, late February or early March to October 1,[20] peak in June and July;[17] in Tennessee May through September.[12]

Temperature: Spawning begins when temperatures approach 21.1[20]–22.2 C,[26] observed at maximum of 32.2 C.[20]

Fecundity: Based on stripping experiments, 120–3977.[6]

EGGS

Diameter 1.3–1.6 mm.[1]

EGG DEVELOPMENT

Incubation period at 21.1 C, 3 days, but age at start unknown;[1] at 23.6 C (SD 0.77) mean varied from 49.3–52.1 hours (combined samples 52.3 hours, SD 5.36); at 28.7 C (SD 0.44) two sets of data, in one, means varied from 26.2–27.4 hours, combined samples 26.6 hours (SD 1.94) while in the other means varied from 27.7–28.4 hours, combined samples 28.1 hours (SD 2.18).[18] A report of incubation lasting 9 days in Puerto Rico[8] is questioned, JDH.

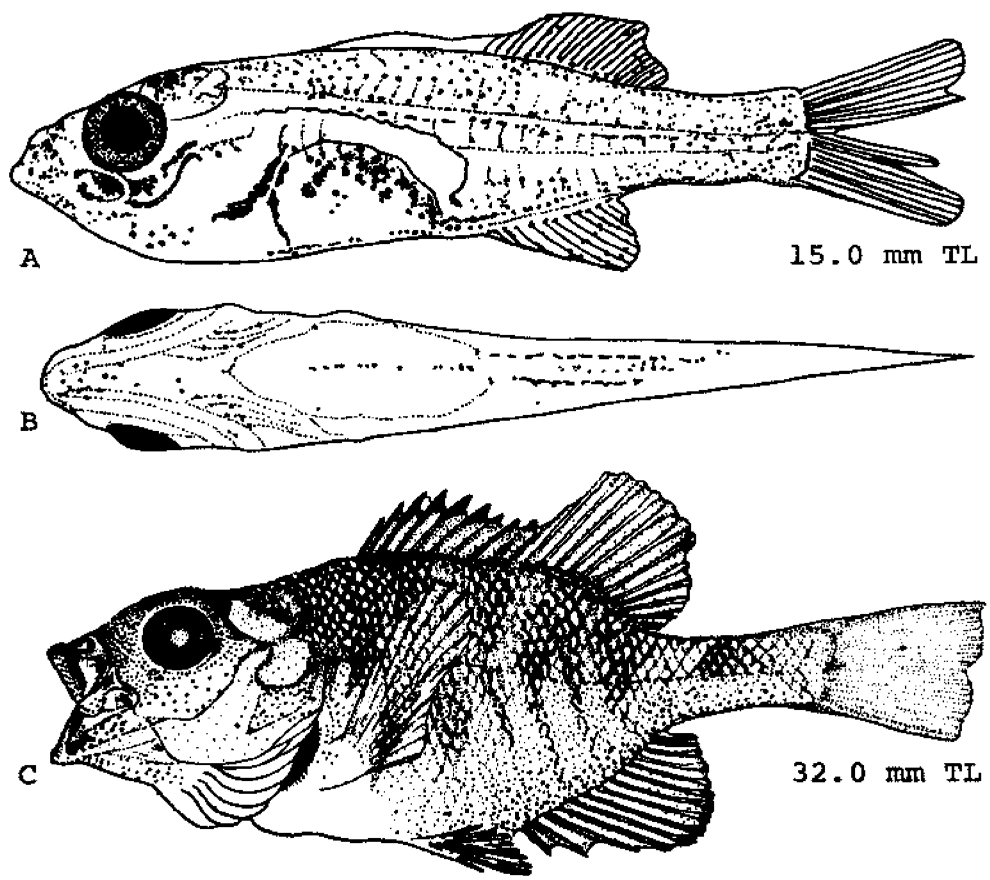

Fig. 140. *Lepomis microlophus*, Redear sunfish. A. Larva, 15.0 mm TL. B. Ventral view of A. C. Juvenile, 32.0 mm TL. (*A, B, Werner, R. G., 1966: figs. 4, 5. C, Meyer, F. A., 1970: fig. 4.*)

YOLK-SAC LARVAE

Minimum size unknown, maximum length described 5.0 mm.

At 5.0 mm pigment developed over gas bladder and yolk, few scattered chromatophores on head, a row of pigment along dorsal wall of gut posterior to gas bladder, and a series of widely spaced chromatophores, approximately one per myomere, ventrally between anus and tail.[3]

LARVAE

Size range described 5.1–14.0 mm.

At 7.0–11 mm a noticeable hump on head. Dorsal and anal fin rays first evident at 8.3 mm; dorsal spines developing at 14.0 mm; pectoral fins rayless at 5.5 mm; caudal fin rays first evident at 6.2 mm; pelvic fins developing at 14.0 mm.

Pigmentation: At 5.1–7.0 mm 2 patches of broad, smudgy chromatophores on top of head; at 7 mm a dark bar of chromatophores on isthmus, this prominent at 9.0 mm, gone at 14.0 mm. At 10.2 mm a narrow mid-lateral line of chromatophores, few chromatophores scattered over body, a prominent patch of chromatophores on top of head, and light pigment apparently developing on top of gas bladder.[1] At 10.0–15.0 mm a conspicuous line of melanophores on breast and belly, and a double line of pigment ventrally beyond anus.[27] At 14.0 mm body more heavily pigmented, chromatophores along rays of soft dorsal fin and upper rays of caudal fin.[1] At 15.0 mm body speckled throughout, pigment developing on vertical fins.[27]

JUVENILES

Minimum size described, 32 mm.[1]

In specimens 17.0–38.0 mm long (thus possibly including some larvae), mean number of pectoral rays 12.19, mean number of precaudal vertebrae 12.03, mean number of caudal vertebrae 17.93, mean number of ribs 10.33.[27]

Pigmentation: At 32 mm body spotted throughout except on breast which is pigmentless; a series of narrow vertical bands on sides, these not well-developed below lateral line; chromatophores in all vertical fins.[1] "Young" like adult females, except breast whitish or whitish yellow, opercular spot light gray or pale yellow, lateral bands more distinct, body more silvery.[2]

AGE AND SIZE AT MATURITY

Minimum age at maturity in Puerto Rico ca. 8 months;[8] in Tennessee during second summer of life;[12] females ripe in North Carolina at 87.5 mm.[2]

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Micropterus dolomieui Lacépède, Smallmouth bass

ADULTS

D. X to XI,[26] 12–15;[57] A. II to III, 10[25]–12;[16] P. 13–15[57] (possibly to 18[23]); V. I, 5;[57] lateral line scales 67[9]–85;[22] scale rows on cheek 16–18;[16] gill rakers on upper limb usually 3,[57] on lower limb ca. 7[26] or 8; precaudal vertebrae 16,[38] total vertebrae 31[57]–33;[38] branchiostegals 6, 6 or 7, or 7; pyloric caeca 7–10.[57]

Proportions as times in SL: Depth 3.35–3.60, head 2.80–2.85.[26] Proportions as percent TL: greatest depth 20.3–28.2, head 26.6–30.5. Proportions as percent HL: eye 14.1–30.0, snout ca. 35.0, maxillary 40.0–46.7.[57] Shortest dorsal spine typically one-half or more length of longest spine.[23,25]

Body robust,[57] laterally compressed.[26] Gape to posterior half of eye in young adults, slightly beyond posterior edge of eye in large adults.[28] Fine, brush-like teeth on both jaws, palatines, and vomer; lower pharyngeal teeth on long, narrow pad, numerous, fine, and uniform in size.[57]

Lateral line complete,[22] slightly arched anteriorly.[26] Dorsal fins joined[57] and with small scales on membranes of their bases. *Pyloric caeca typically unbranched.*[27]

Pigmentation: Dorsal surface brown, golden brown,[9] yellow-green,[9] olive, or green,[57] usually mottled with darker shades, and with bronzy reflections.[9] Sides lighter than back,[57] the scales usually with bronzy[24] or golden *flecks; 8–16 prominent to vague vertical bars on sides.*[9,57] Ventral surfaces pale bluish gray,[16] silvery,[24] yellow-white,[9] cream,[57] or white tinged with light gray,[9] or milk white.[57] A single olive green bar from snout to eye, and 3–5 similar bars from eye across cheek and opercle; opercular flap with a moderate-size dusky spot;[9,16] eye red, orange,[57] or reddish brown.[16] Fins, except pectorals, dark to amber, opaque and with some black on rays, spines, and membranes; pectoral fins clear. Peritoneum

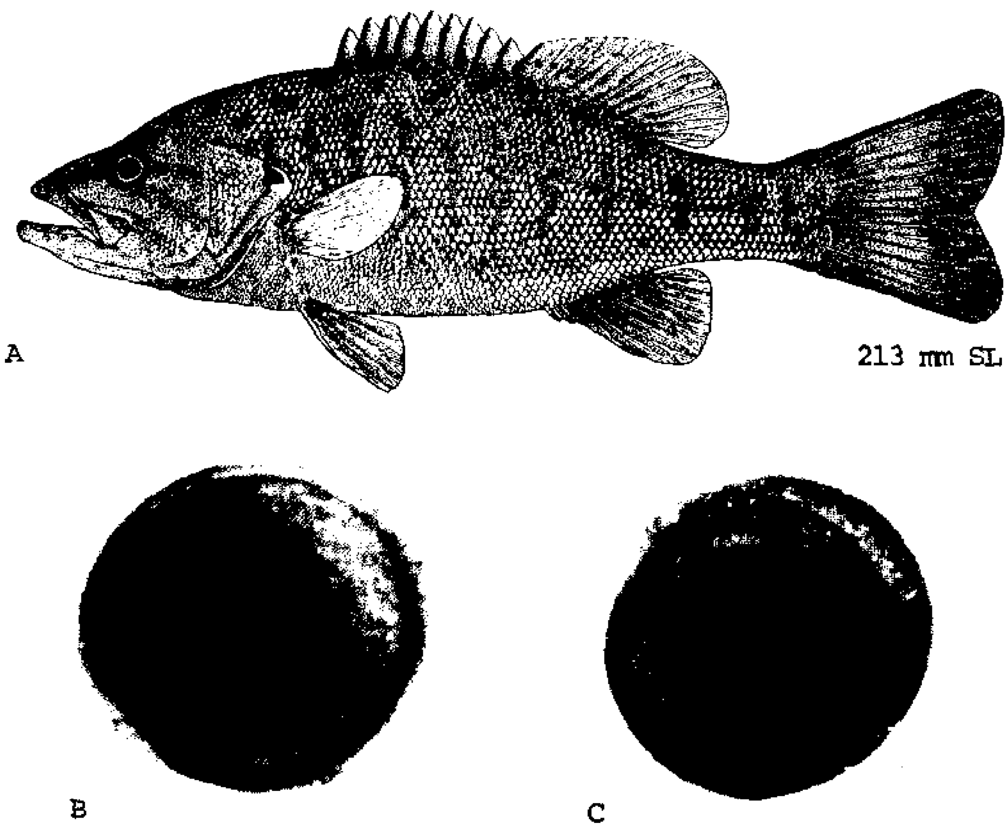

Fig. 141. *Micropterus dolomieui*, Smallmouth bass. A. Adult, 213 mm SL. B, C. Typical eggs, showing relative size of oil globule and developing embryo. (*A, Trautman, M. B., 1957: fig. 129. B, C, Reighard, J., 1906: fig. 1.*)

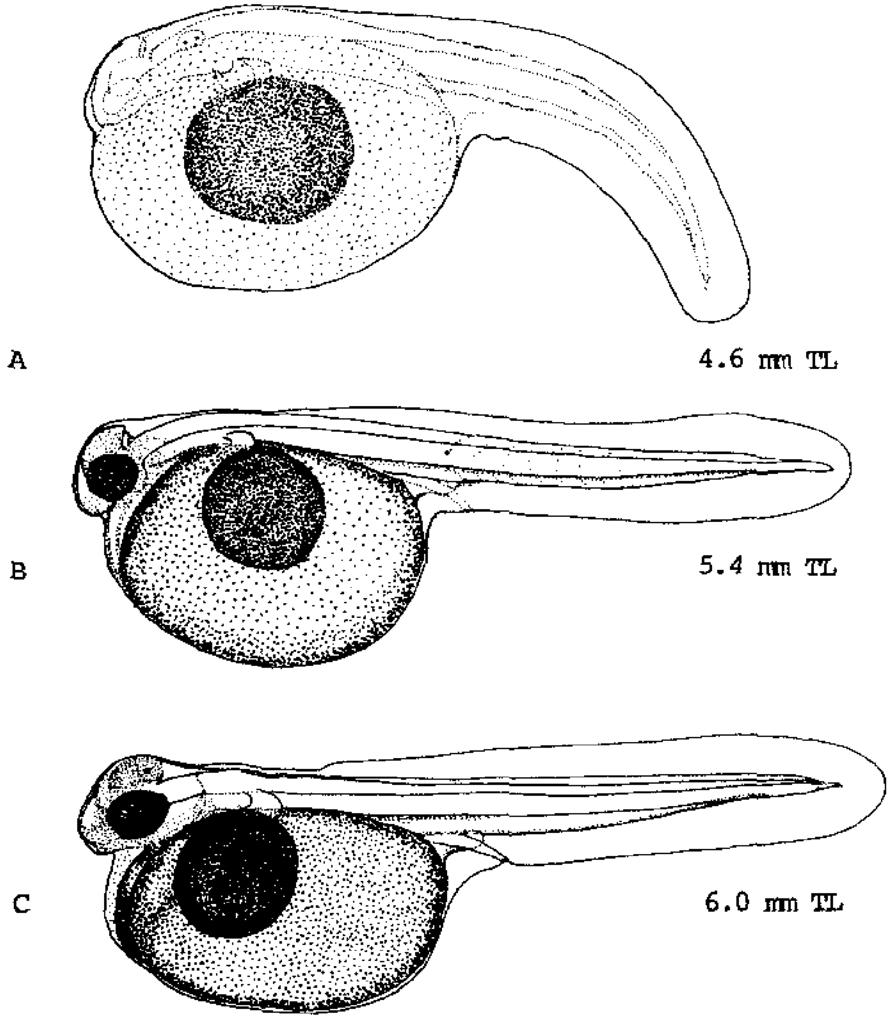

Fig. 142. *Micropterus dolomieui,* Smallmouth bass. A. Yolk-sac larva, 4.6 mm TL. B. Yolk-sac larva, 5.4 mm TL. C. Yolk-sac larva, 6.0 mm TL. *(A-C, Reighard, J., 1906: figs. 4–6, Joan Ellis, delineator.)*

silvery.[51] Spawning males dark greenish bronze, the back markings and lateral bars blackish,[9] eyes more red.[29] Spawning females pale, light green or yellowish, strongly mottled with spots or bands.[13]

Maximum length: 686 mm.[57]

DISTRIBUTION AND ECOLOGY

Range: Originally from the St. Lawrence drainage, Quebec, southward, west of the Allegheny Divide, to northern Georgia and Alabama; absent in most of Mississippi valley north to southern Illinois and southwestern Indiana; west of the Mississippi, south through central Missouri and Arkansas to northeastern Oklahoma; northward through parts of Kansas, western Missouri, Iowa, Minnesota, and northeastern South Dakota; east from northern Minnesota through Wisconsin to Lake Michigan; northeastward through southern Ontario to Quebec.[59] Now introduced into parts of all states outside the native range except Louisiana and Florida; also south-central and southwestern Canada, Hawaii, Asia, Africa, Mauritius Island, Europe, and South America (although present status there unknown).[3,33,34,41,46,47,52,53,57,59]

Area distribution: Introduced in Rappahannock River; now northward along western edge of Chesapeake Bay to Havre de Grace;[8,36] also introduced in Delaware and New Jersey.[58]

Habitat and movements: Adults—found in clear, cool water,[3,41] in streams,[8,29] rivers,[55,57] lakes,[15] ponds,[41] and sinkholes;[19] in flowing water, usually in areas having moderate current[41] such as riffles[9] or pools below riffles,[15] and in water more than 1.2 m deep; in lakes, generally along rocky shorelines, or over bars, shoals, reefs, or rocky ledges in water having minimum depth of 1 m.[3,9,15] Typically over bottoms of rock, sand,[7,55,56] or gravel;[9,42] definitely avoids muddy bottoms. Usually found in protected areas;[7] thus associated with rocks of shoals, talus slopes, and submerged trees, roots, and logs; infrequently among aquatic vegetation.[52,55,57] Upper lethal temperature 35 C;[57] at 4.4 C become torpid[41] and temperatures "near freezing point" are lethal;[52] preferred temperatures variously estimated between 20.3 and 28.0 C.[41,57] Maximum salinity 7.39 ppt.[26] Maximum depth, 24.4 m.[39] Maintain fairly restricted home ranges[41,42,49] and movements typically limited to 0.8[57] to 14.5 km[21] (in one Tennessee study maximum recorded movement in one season was 5.3 km,[48] while in another study specimens released an average of 103.7 days traveled an average of only 1.3 km; only 8 percent of bass tagged in Lake Huron moved more than 8 km in one year[51]); but in St. Lawrence River, Canada, movements of up to 48 km have been recorded.[57] In rivers migrate upstream to spawn;[9] in lakes run up tributary streams.[39] Congregate on spawning grounds in spring, move off to deeper water in summer. Males apparently home to previous nest site or vicinity of previous nest site.[57] At night at bottom,[41] hide in cavities or depressions,[56] under rocks or piles of twigs,[42] or actually enter substrate.[41] In winter move into considerably deeper water[9] and form aggregations[39,57] among rocks and ledges at bottom,[4,7,16] also hide in holes.[41]

Larvae—initially in compact group on rocks of nest; fall

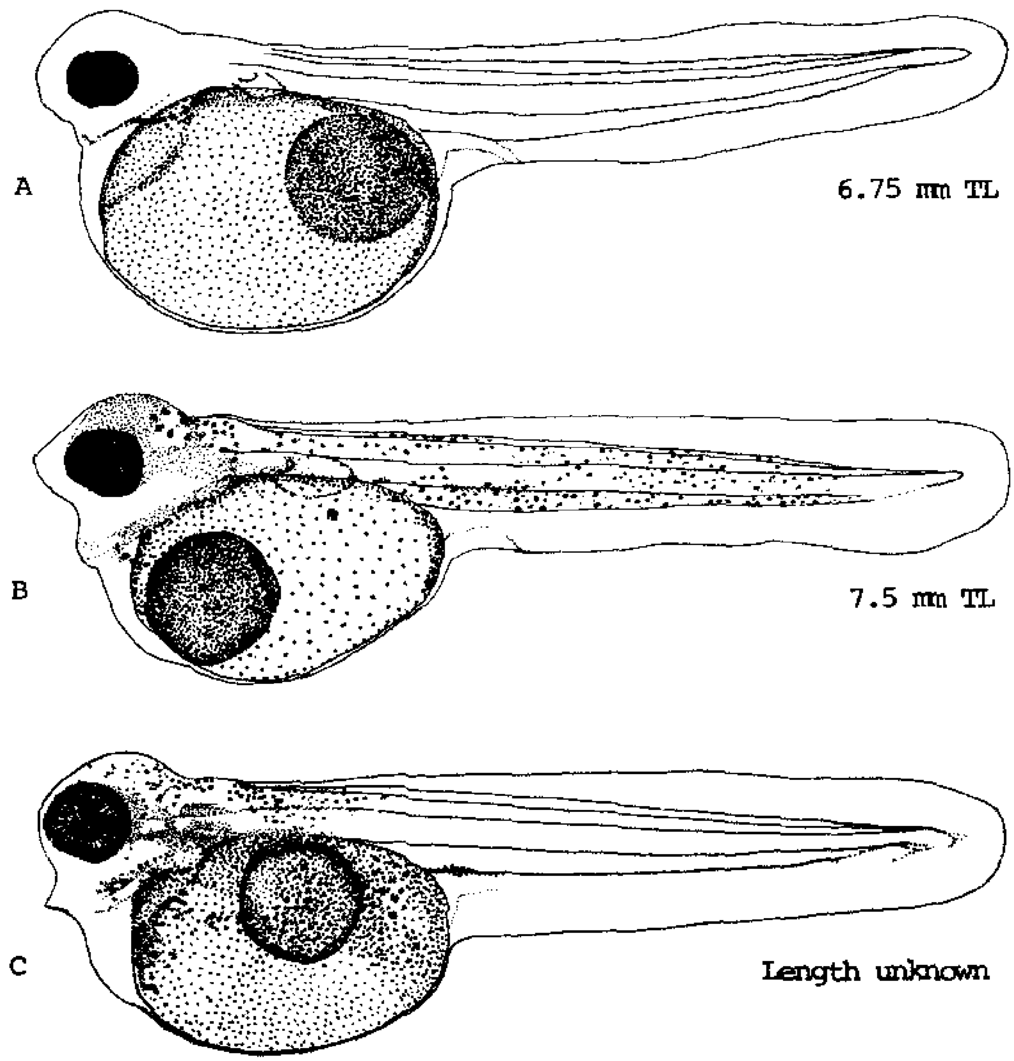

Fig. 143. *Micropterus dolomieui*, Smallmouth bass. A. Yolk-sac larva, 6.75 mm TL, 3 days after hatching. B. Yolk-sac larva, 7.5 mm TL, 6 days after hatching. C. Yolk-sac larva, length unknown, seven days after hatching. (*A-C, Reighard, J., 1906: figs. 8–10, Joan Ellis, delineator.*)

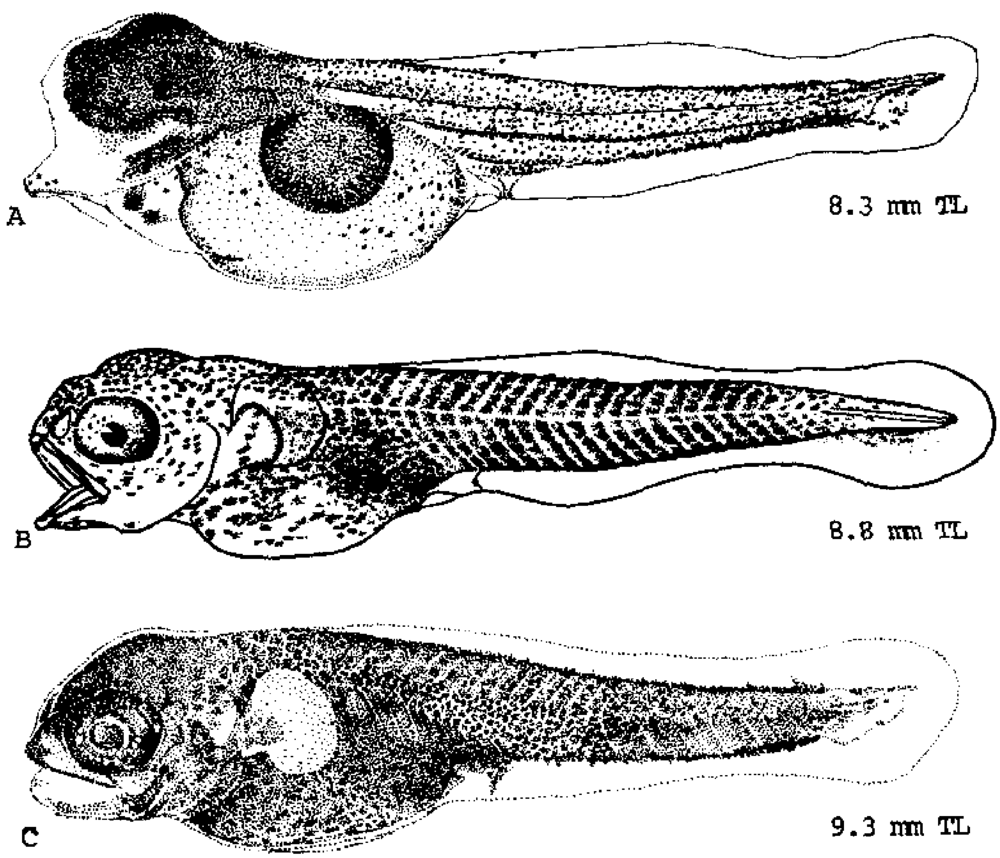

Fig. 144. Micropterus dolomieui, Smallmouth bass. A. Yolk-sac larva, 8.3 mm TL. B. Yolk-sac larva, *8.8 mm* TL. C. Yolk-sac larva, 9.3 mm TL. *(A, C, Reighard, J., 1906: figs. 11, 13, Joan Ellis, delineator. B, Fish, M. P., 1932: fig. 114.)*

into crevices between rocks 1 or 2 days after hatching [4,33,40] and remain among rocks for several days.[3,7,41,52] Swim from nest in dense schools [41] at lengths of 8.7–9.4 mm.[12] Age at time of swim up variously estimated at 5 days after deposition [32] to ca. 8 [40]–13 days [7] after hatching (at temperatures of ca. 18.3–21.1 C in ca. 11 days [17]). Remain in vicinity of nest for 4 [3]–9 days [5] or to length of ca. 9 3 [40] C to ca. 32 mm.[7] With continued growth, schools range further from nest and become diffuse.[41] Older larvae typically in shallow water along shore [40] or near mouths of creeks.[6] Larvae guarded by male parent [51] for 0 [12] to 28 days after rising (thus, in some cases, at least, throughout larval period [52]). Maximum recorded depth, at 9.5–10.0 mm, 6 m.[6] Upper TL 50 for 2-day-old yolk-sac larvae 35.0 C, for larvae 32.8 C.[41]

Juveniles—guarded by male parent to maximum length of ca. 25 mm; [52] typically inshore in calm marginal areas such as sandy shoals; [7,29,48] also near margins of vegetation [7] (but avoid thick weed beds); seek cover in lee of rocks; [43] found over bottoms of sand,[7,30] rock,[41] gravel,[30] rubble,[55] and, rarely, mud.[7] After 2nd growing season move into deeper water.[29] Upper TL 50 for fingerlings 32.2 C. In one experiment juveniles ca. 50 mm long changed color and became immobile at 10 C, 95% died at 5 C; in another experiment in which fish were acclimated to 15 C, lower TL 50 ca. 1.7 C.[41]

SPAWNING

Location: Lakes,[39,41] ponds,[11,40] sloughs,[53] rivers,[12] and streams.[9] In lakes typically along rocky shorelines,[12] rarely in patches of vegetation,[10] avoid strong current or wave action.[41] In streams sometimes in current, other times in deep pools with little current; [52] typically in streams 5–30.5 m wide having gradients of 1.3–4.7 m/km.[9] Spawn over bottoms of gravel [3,41,52,55,57] (preferred substrate [40,50]), rock, rubble,[50,55,57] sand,[3,6,41] mixtures of sand and rootlets,[50] broken shell, or woody debris; [41] when these substrates not available may spawn on silt or clay [52] (but in experimental studies refused to spawn on mud [41]), and known to dig 15–25 cm of ooze in order to spawn on underlying roots and debris; [17] also sometimes spawn on roots of old logs, bare wooden planks,[11] and in artificial nest made of Spanish moss.[40] Usually seek cover of rocks,[4,13] stumps,[41,52] logs,[15,57] banks,[52] fallen trees,[12] dense vegetation (rarely [4,57]), and dead aquatic plants.[50] Depth, 20 cm [40] to 6 m; [57] but averages stated as 47.0–69.8 cm.[32,50] Distance out, 3–9 m.[52]

Nests: Guarded by male [54] *(and possibly also sometimes* by female, although this is questioned [41]); circular, concave; diameter ca. 295–1220 mm; [4] average diameter reported as 351 [37] and 483 mm; [50] depth ca. 50–100 mm.[41] Nest bottom comprised of sand [13] and stones; [14] smaller *stones at edge of nest, larger stones* [40] *(up to ca. 125 mm* in diameter) [4] in center; [40] stones in bottom of nest free of sediment and polished.[52] Minimum distance between nests, 12 m. In lakes 1 nest/17–63 m ^{2}, in rivers 3–257 km.[41]

Season: Typically April to July; [4,6,7,15,29,33,34,35,53,55] in Arkansas reported as early as March,[20] and in Washington state as late as August.[53] The total spawning period may vary from 28 [4] to 62 days.[45]

Frequency: May spawn 2 [32]–3 times in one season,[3] with each spawning peak lasting 3 [32]–10 days.[57]

Time: During daylight hours; [52] specifically recorded from 1230–1450 hours.[18,40]

Temperature: Move into spawning areas at temperatures as low as 4.4 C.[9,52,57] Males begin nest building at 15.0 C.[5,36] Actual spawning observed over temperature range of 12.8 [53]–26.7 C,[55] but spawning probably not successful below 18.3 C [5,36] and apparently inhibited below 17.8 C.[57] Spawning typically occurs on rising temperatures.[4,37]

Fecundity: A minimum of 1363 eggs reported, but this fish may have already spawned; otherwise 4964 [55]-20,825; [44] average 10,000; [3] eggs/kg of fish 4400–17,600.[55]

EGGS

Location: Demersal.[57] Initially attached to each other [41] and to stones in the nest; [4,29,52] ultimately lose adhesiveness and fall into spaces between stones.[41]

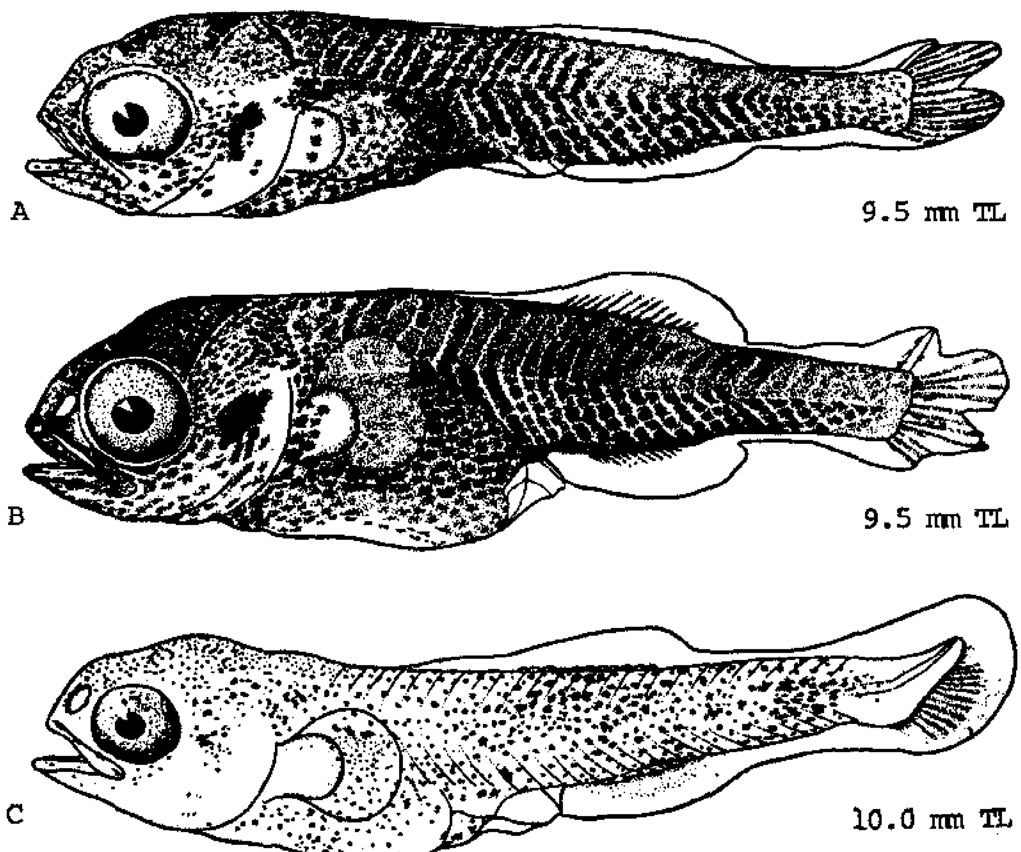

Fig. 145. *Micropterus dolomieui*, Smallmouth bass. A. Larva, 9.5 mm TL. B. Larva, 9.5 mm TL. C. Larva, 10.0 mm TL. *(A-C, Fish, M.P., 1932: figs. 115–117.)*

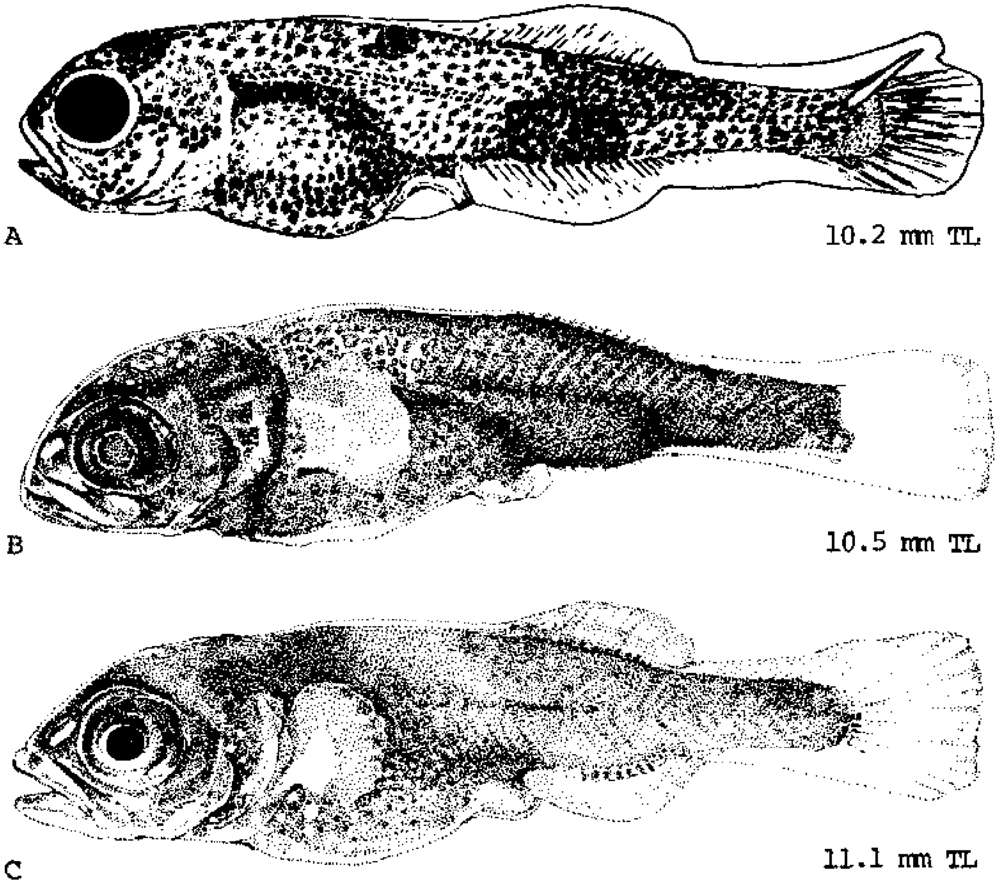

Fig. 146. *Micropterus dolomieui*, Smallmouth bass. A. Larva, 10.2 mm TL. B. Larva, 10.5 mm TL. C. Larva, 11.1 mm TL. (*A, Meyer, F. A., 1970: fig. 1. B, C, Reighard, J., 1906: figs. 14–15, Joan Ellis, delineator.*)

Ovarian eggs: Three size classes in ovaries simultaneously; ca. 2.5 mm, 0.5–1.5 mm, and ca. 0.25 mm, the largest of these opaque, but apparently ripe.[40]

Fertilized eggs: Variously described as grayish white,[4,41] white, opaque,[18,40] light amber,[41] and pale yellow; diameter 1.2[57]–2.8 mm,[40] averages given as 2.0[1] and 2.5 mm;[14] chorion with outer adhesive membrane and inner zona radiata pierced by radial canals; yolk light yellow, transparent, homogenous at center, granular at edges; a single large oil globule and numerous small ones; perivitelline space narrow (in eggs 2.17–2.80 mm in diameter, varied from 0.054–0.096 mm[40]).

EGG DEVELOPMENT

Incubation at various temperatures:

At 12.2 C	ca. 10 days[41]
At 12.8 C	9.5–10 days[52]
At 15.0 C	9 days[52]
At 15.6 C	6 days[10]
At 19.4 C	3.75 days[52]
At 21.1 C	ca. 4 days[1]
At 21.7 C	3.5 days[52]
At 22.2 C	2 days[52]
At 23.9 C	2.25 days[52]
At 25.0 C	2 days[41]
At 25.6 C	2.5 days[52]

Reports of 21 days at 15.0–15.6 C,[10] and 14 days at 17.8–4.1 C,[5] and of incubation at unspecified temperature lasting up to 16 days[10] are questioned (JDH). Eggs will hatch at 10.0 C, and can withstand exposure to 4.4–7.2 C for 5–20 hours.[45] Eggs will survive temperature rise from 11.7–25.0 C, and eggs developing at 18.3 C can be successfully transferred to various temperatures between 10.0 and 23.9 C.[52] Eggs have been observed in the field at temperatures of 11.1–26.7 C.[30] Greatest vulnerability to temperature stress occurs at the beginning and end of the incubation period.[10,41]

YOLK-SAC LARVAE

Minimum length at hatching, 4.6 mm,[40] *but at one day* after hatching average length 5.7 mm, range 5.6–5.9 mm; [12] length at end of stage 8.7–9.9 mm.[57]

Myomeres 10 + 19.[6]

At 8.8 mm TL, length to vent 4.0 mm, greatest depth 1.8 mm, eye diameter 0.85 mm.[6]

At hatching head deflected, attached to yolk.[40] At 8.8 mm TL head and yolk region robust, body compressed behind anus.[6] Yolk somewhat elongate at hatching, its lower side adhesive. Mouth open at 6.0 mm, lower jaw evident at 6.75 mm.[40] Gape extended to middle of pupil at 8.8 mm.[6] At hatching a single nasal opening. Choroid fissure visible to at least 9.3 mm.[40] Dorsal, anal, and caudal fins still connected by finfold at 10.5 mm. At 5.4 mm (1 day) pectoral buds thin, low, semicircular ridges lying parallel to axis of body; at 6.75 mm shifted to 45° angle; at 7.5 mm triangular in shape; [40] at 8.8 mm still rayless; [6] at 10.5 mm nearly vertical (perpendicular to axis of body). Notochord oblique in some individuals at 9.3 mm. Gas bladder developing at 9.3 mm.[40]

Pigmentation: At hatching body colorless, transparent; yolk pale yellow; oil globule bright golden. At 5.4 mm (1 day) pigment developing in eye. At 6.0 mm chromatophores in band from pectorals posteriorly along junction of yolk sac and body. At 6.75 mm (3rd day) eye completely black, a second pigment band parallel to first and extending from auditory vesicle backward along body. In an older specimen of the same size (4th day) both pigment bands extended posteriorly to tail, iridescent golden pigment on surface of eye. At 7.5 mm sides of body essentially covered with dark pigment; pigment

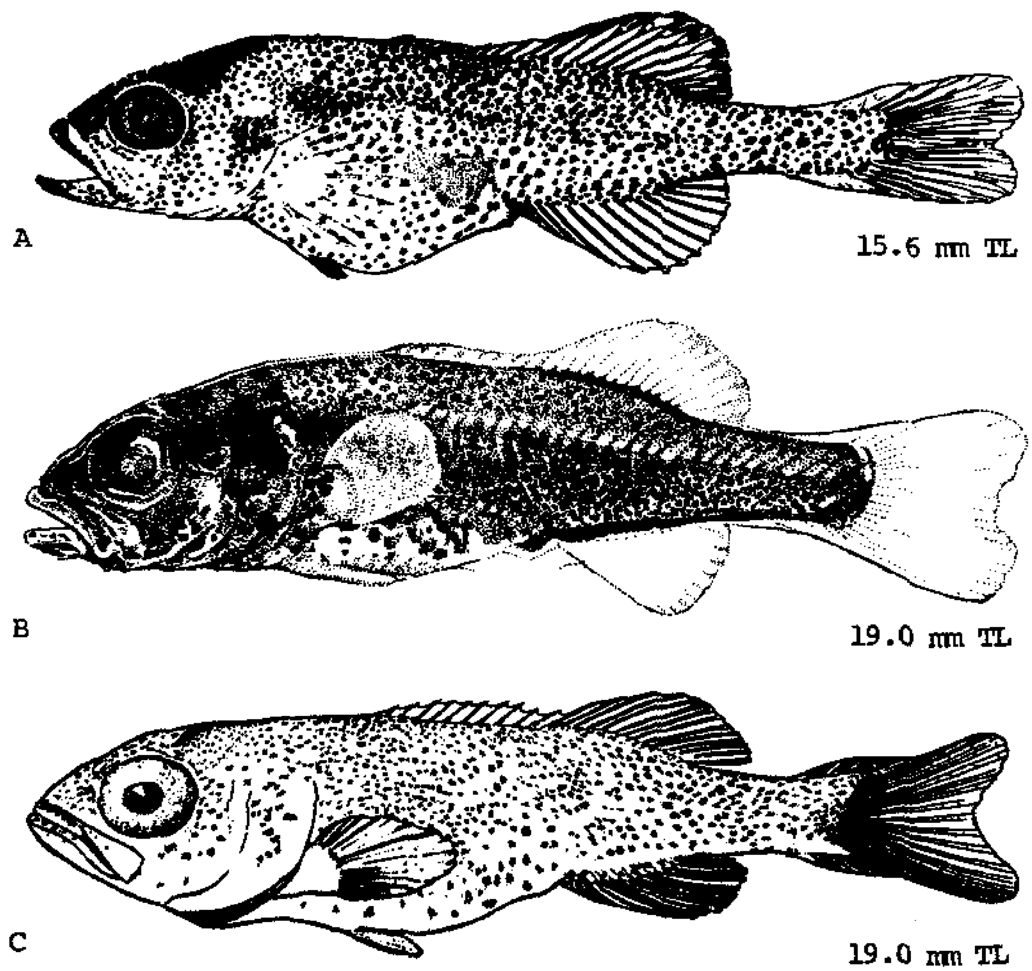

Fig. 147. *Micropterus dolomieui*, Smallmouth bass. A. Larva, 15.6 mm TL. B. Larva, 19.0 mm TL. C. Larva, 19.0 mm TL. (*A, Meyer, F. A., 1970: fig. 1. B, Reighard, J., 1906: fig. 16, Joan Ellis, delineator. C, Fish, M. P., 1932: fig. 118.*)

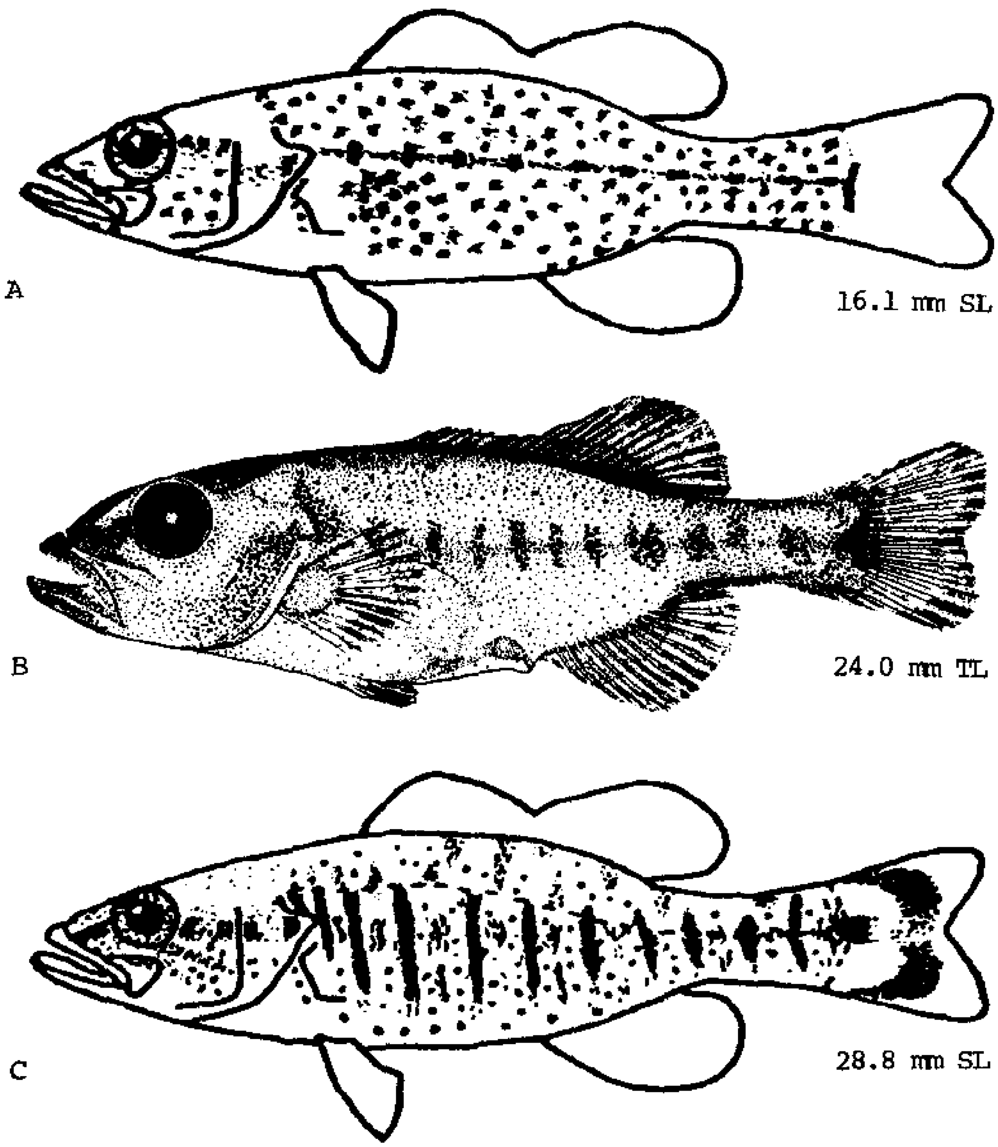

Fig. 148. *Micropterus dolomieui*, Smallmouth bass. A. Juvenile, 16.1 mm SL. B. Juvenile, 24.0 mm TL. C. Juvenile, 28.8 mm SL. (*A, C, Ramsey, J. S., and R. O. Smitherman, 1972: fig. 4. B, Meyer, F. A., 1970: fig. 1.*)

also on head, lower jaw, and dorsal part of yolk sac. At 8.3 mm eye wholly iridescent. At 9.3 mm entire body, except ventral side of yolk sac, covered with dense black pigment.[49]

LARVAE

Size range described, ca. 8.7 [1]–19.0 mm TL.

Myomeres 10–11 + 19–22.[6]

At 9.5 mm, length to anus 5.1 mm, greatest depth 2.1 mm, diameter of eye 1.0 mm. At 10.0 mm, length to anus 5.25 mm, greatest depth 2.17 mm, eye 1.0 mm. In a somewhat more advanced larva of 9.5 mm, length to anus 5.0 mm, head length 2.6 mm, greatest depth 2.6 mm, eye 1.0 mm. At 19.0 mm, length to anus 9.6 mm, head length 5.4 mm, greatest depth 4.3, eye 1.5 mm.[6]

At 9.5 mm head deep, body gradually tapering to tail; in a more advanced larva of same size, abdomen noticeably deeper than head. At 19.0 mm lower jaw projected, maxillary to middle of pupil.[6]

At 11.1 mm finfold continuous between dorsal, anal, and caudal.[49] Dorsal and anal rays forming at 9.5 [6]–10.0 mm;

dorsal spines evident at 15.6 mm; pelvics first evident at minimum length of 15.6 mm; urostyle oblique at 10.2 mm; [1] at 9.5 mm intestine becoming coiled.[6]

Pigmentation: At 10.2 mm body covered with chromatophores, but with concentrations on head, over gut, and on body between anus and caudal base.[1] At ca. 12.0 mm black body pigment tinged with green and bronze.[40] At 15.6 mm pigment even over body, a distinct dark spot over head, ventral pigment reduced. At 19.0 mm sides of body with stellate and round chromatophores; three longitudinal rows of chromatophores on either side of dorsal ridge and a single line on either side of ventral ridge behind vent; head less pigmented than body; ventral surfaces light; fins colorless; peritoneum black;[6] in life whole body uniform gray-green fading to white below.[40]

JUVENILES

Minimum size described, 16.1 mm SL.[68]

In specimens less than ca. 125 mm long, gape to below center of eye.[28] Scales first evident over size range of 18.0–22.0 mm, first appear on caudal peduncle just anterior to caudal fin, spread predominately anteriorly, less rapidly dorsally and ventrally, and least rapidly caudally.[2,31]

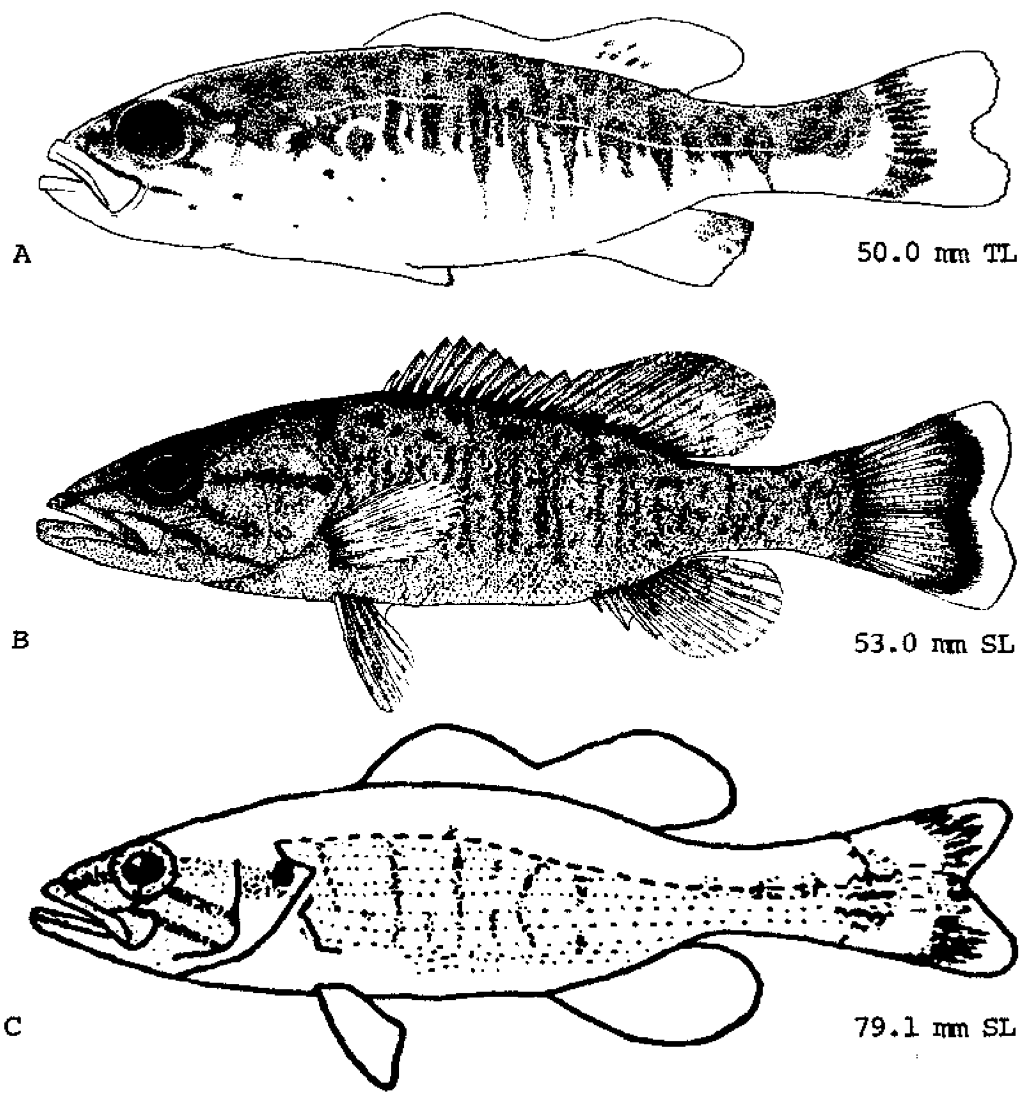

Fig. 149. *Micropterus dolomieui*, Smallmouth bass. A. Juvenile, 50.0 mm TL. B. Juvenile, 53.0 mm SL. C. Juvenile, 79.1 mm SL. (*A, Reighard, J., 1906: fig. 17, Joan Ellis, delineator. B, Trautman, M. B., 1957: 129. C, Ramsey, J. S., and R. O. Smitherman, 1972: fig. 4.*)

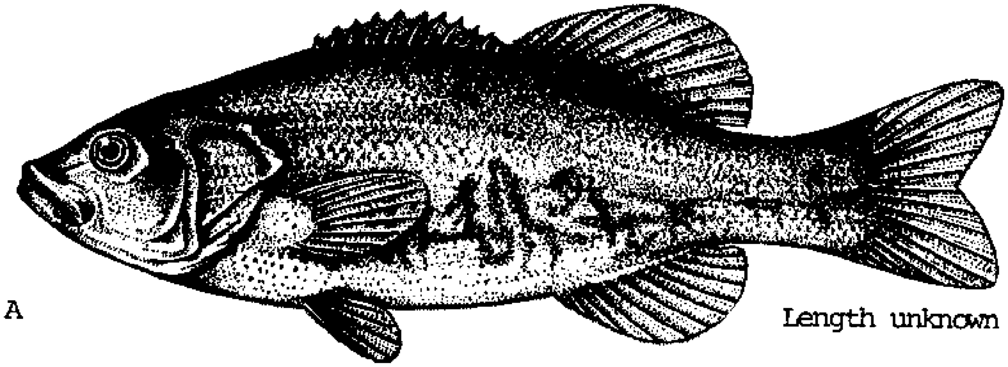

Fig. 150. *Micropterus dolomieui*, Smallmouth bass. A. Juvenile, length unknown. (*A, Sterba, G., 1959.*)

Pigmentation: At 15.1 mm SL a faint, narrow lateral stripe along horizontal intermuscular septum, large melanophores over entire body. At time of scale formation, lateral stripe obliterated.[58] At ca. 19.0 mm TL dark vertical bands (ultimately numbering 10 [40]–16 [9]) on body, a black spot at base of tail, and a dark band across tail.[40] At ca. 24.0 mm vertical bands well-developed, body pigment less concentrated than in previous stages.[1] At 28.8 mm SL caudal fin tricolored (opaque pale yellow to yellow-orange before dark band, iridescent white behind).[58] At ca. 50.0 mm stripes well-developed on head.[40] At ca. 64–100 mm greenish blue or greenish brown, mottled with brown, the mottling most conspicuous above lateral line; 5 brownish stripes on sides of head back of and below eye; lower parts of head and parts of opercle sky blue; abdomen grayish white; dorsal dusky and light brown; caudal dusky at base, median part yellowish brown, distally black, margined with white or salmon red; anal dusky yellow, slightly mottled, margined with white; pectorals and pelvics yellowish.[26] "Young" also described as dull yellowish green.[38]

AGE AND SIZE AT MATURITY

Minimum age at maturity, 2 years;[7,39,41,52] minimum length at maturity, females at 195.0 mm.[7]

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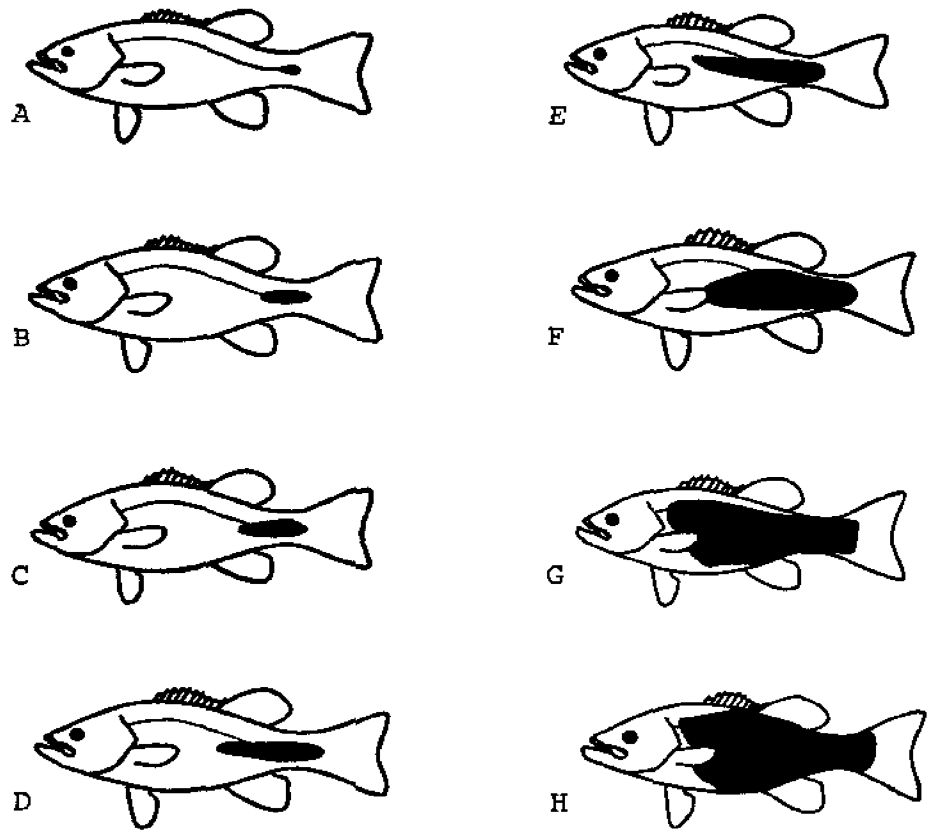

Fig. 151. *Micropterus dolomieui,* Smallmouth bass. Scale development through a size range of 21.0 to 32.0 mm FL. A. 21.0 mm FL. B. 21.6 mm FL. C. 21.9 mm FL. D. 23.0 mm FL. E. 24.9 mm FL. F. 26.1 mm FL. G. 31.1 mm FL. H. 32.0 mm FL. *(A-H, Everhart, W. H., 1949: 113.)*

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Micropterus salmoides (Lacépède), Largemouth bass

ADULTS

D. X[25] (although West and Heston report an average of *9.26 spines*[85]*),* 11[12]–14[133] *(average 12.84*[85]); A. II *to III*[25] (average 3.09[85]), 10–12[12] (average 10.74[85]); P. 13–15; V. I, 5; lateral line scales 51–77[54] (average 62.56[85]); cheek scales 9–12[25] (average 10.8[85]); scales above lateral line 8, below 17–19;[34] scales from lateral line to anal origin 14–18;[133] caudal peduncle scales 24–34;[54] gill rakers lower limb 6–8;[35,133] branchiostegal rays 6, 6 and 7, or 7;[133] pyloric caeca variously stated, 12[143] to ca. 43–53,[54] 24–28 with at least 6–10 branched; vertebrae 30[133]–33[53] typically 32, in *M. salmoides salmoides* 15 + 17, in *M. salmoides floridanus* 14 + 18.[57]

Proportions as times in SL: Head 2.8–3.05, depth 2.95–3.3.[35] Proportions as percent TL: Greatest depth 20.9–29.7, head 26.6–31.7. Proportions as percent HL: Eye 12.8–20.5, snout 25–28.[133] Shortest dorsal spine less than one-half length of longest.[32,36]

Body robust,[133] compressed;[31] angle from snout to dorsal fin low; back more or less flat; caudal peduncle long, deep;[133] head relatively long;[34] a deep notch over eyes; mouth terminal, slightly oblique; gape to middle of eye; maxillary to posterior margin of eye. Fine brush-like teeth on both jaws, palatines, and vomer; lower pharyngeal teeth on long, narrow pad, numerous, fine, and of uniform size.[133] Lateral line complete, slightly arched anteriorly.[34] Spinous dorsal separated from soft dorsal by a deep notch extending almost to base of fin;[33] anal and soft dorsal without scales on basal membranes.[35]

Pigmentation: Bright green to olive or olive-yellow above with brassy or gold luster; sides olive yellow with silvery sheen, light green or golden green, sometimes darker; a black lateral band (but broken, inconspicuous, or, sometimes, absent in large adults); some additional black spots above and below lateral band; venter milk white, greenish white, yellow, or silvery; sides of head olive to golden green with scattered black pigment or three distinct stripes on cheeks and opercle; a moderate sized black spot on opercle; eye brownish or dull reddish; in-

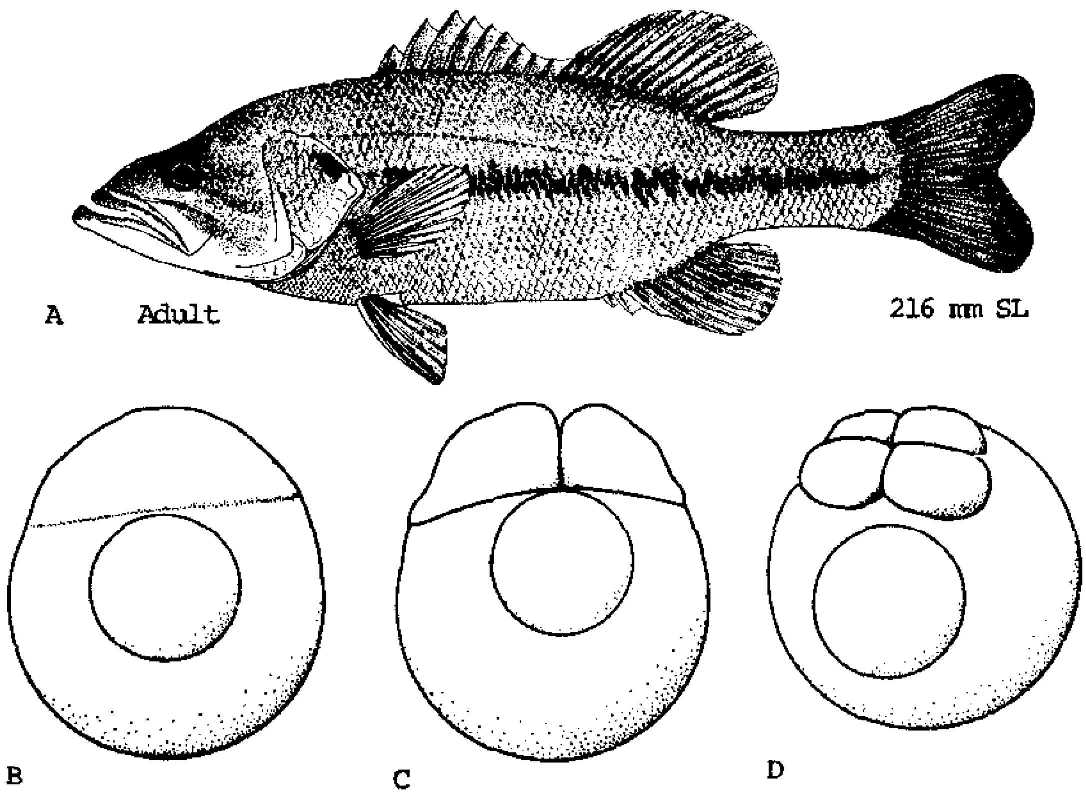

Fig. 152. *Micropterus salmoides,* Largemouth bass. A. Adult, 216 mm SL. B. Fertilized egg, 35 minutes old, blastodisc developed (chorion removed). C. 2-cell stage, 1 hour. D. 4-cell stage, 1 hour and 15 minutes. *(A, Trautman, M. B., 1957: fig. 131. B-C, Carr, M. H., 1942: figs. 1–3.)*

side of mouth milk white; dorsal opaque, green or olive; anal green to olive with some white markings; caudal green to olive, pale basally, darker toward margin and with whitish edge; pectoral amber, clear; pelvics green to olive with white markings.[12,25,33,35,133] Vivid color changes occur during spawning.[56]

Maximum length: 876.3 mm.[10]

DISTRIBUTION AND ECOLOGY

Range: Original range probably from James River, Virginia, to Rio Conchos (a tributary of the Rio Grande), Chihuahua and Santa Engracia, Tamaulipas, Mexico, north from Texas through western Oklahoma, central Kansas, eastern Nebraska, western Iowa, most of Minnesota and Wisconsin, and North Dakota; throughout most of the Great Lakes basin except Lake Superior; north in Canada to Ottawa River system; southeastward to upper Ohio River drainage in western New York, western Pennsylvania, Ohio, West Virginia, and, possibly, western Maryland. Introduced throughout New England and western United States as well as in most of Mexico, and in Canada in Quebec, British Columbia, Saskatchewan (although apparently not established there), and Manitoba.[62,133,134] Also introduced throughout much of Europe (specifically in Finland,[72] Germany,[73] France,[5] England, Scotland,[133] and Spain [124]), Africa,[26,86,99] Mauritius,[113] the West Indies (Puerto Rico [22] and Cuba [29]), the Philippines,[46] Hong Kong, and Brazil.[133]

Area distribution: All tributaries of Chesapeake Bay in Maryland and Virginia; [11] Delaware River estuary; [135] introduced in New Jersey in 1871,[136] but no specific records for tidal waters (JDH).

Habitat and movements: Adults—recorded in both clear [58] and slightly turbid water [81] in small lakes; [5,71] shallow bays of larger lakes; [133] ponds; [8,12] bayous; [10,86] marshes; [89] impoundments; [86] sloughs; [116] and sluggish areas,[10] backwaters,[5] and oxbows [12,58] of river,[5,10] streams,[14,34,71] and creeks. Found over bottoms of mud,[10,38] muck, organic debris, sand, clay, gravel,[12,86] and, rarely, rock.[133] In lentic waters mostly in littoral zone [81] and, during summer, mostly in epilimnion; [67] sometimes in highly eutrophic lakes.[92] Typically associated with vegetation [5,8,10,11,58] such as water lilies, cattails, and pond weed [133] and with various kinds of cover such as submerged trees, stumps, roots, brush, and piers.[5,10,41,58] Maximum reported mean depth, 22.2 m.[102] Maximum elevation, 2100 m.[138] Temperature range observed in field 0.56 [20]–35.0 C, also recorded under field conditions with maximum body temperature of 35.6 C; [141] preferred temperature in field 26.6–27.7 C, but in laboratory 30.0–32.0 C; [91,133] highest recorded upper lethal temperature 37.0 C; [5] other lethal temperatures 5.5 and 32.5 C when acclimated at 20 C, 34.5 C when acclimated at 25.0 C, 11.8 and 36.4 C when acclimated at 30.0 C; [88] become inactive below 10.0 C, and have difficulty maintaining equilibrium at 5.0 C.[86] Upper temperature tolerance appears to vary geographically; thus highest temperature for long-term survival in *M. salmoides salmoides* ca. 36.5 C, in *M. salmoides floridanus* ca. 34 C.[138] Maximum recorded salinity 32.1 ppt,[45] but salinities between 9 and 15 ppt are lethal over prolonged periods.[15,53] Reported from pH range 4.7–11.0.[139]

The species may be comprised of both mobile and sedentary populations as was suggested by Moody working in the St. Johns River, Florida.[82] In some populations movements may not exceed 8 km.[133] In Illinois 59% of 96 recaptures reported were within 30 m of the point of release, 83% were within 61 m, and 96% were within 91 m. The extent of movement did not increase with time.[85] In three different California lakes the average distances traveled were 1.1, 1.9, and 7.2 km.[96] Specimens tagged in Tennessee moved an average of 6.4 km in an average of 47 days.[100,103] Warden, and Warden and Lorio, working in Mississippi, found that home ranges never exceeded ca. 100 m.[78,128] Some long-range movements do occur. In Ohio, fish moved up to 330 km from the point of release.[110] Eighty-four percent of specimens tagged in Florida moved less than 8 km, but the maximum distance was 20 km.[77] In Alabama, tagged fish, moving both upstream and downstream, moved a maximum distance of 35 km in 23–77.9 days, but the average distance was only 4.3 km.[102] In Tennessee, recaptured fish had moved a maximum of 25.7 km,[109] and, in California, a maximum of 29 km.[121] In Louisiana, tagged specimens moved upstream an average of 11.4 km in an average of 374 days, downstream an average of 23.2 km (range 11.8–17.0 miles) in 132–179 days (average 155.0 days).[93] In Missouri, fish either did not move at all or moved both up and downstream averaging 10.3 km in an average of 127.4 days upstream and 19.0 km in an average of 290.7 days downstream.[122] The species is apparently capable of homing.[40,58] Apparently move inshore to spawn; [58] in spring move into shallow bays, channels, and sluggish streams.[5] Move into deep water in winter [58,102] and hibernate under rocks, logs, and mud [10] (although also sometimes move into warm water discharges in winter [58]). Often move into shallow water in evening and stay until dawn, retreat into deeper water or shade by day; [5] remain relatively inactive at night,[98,132] sometimes resting on substrate; [58] diurnal movements decrease and nocturnal movements increase at temperatures above 27 C; below 10 C all movements decrease.[56]

Larvae—at hatching lie on sides on bottom, ultimately fall between sticks, roots, and sand grains; on second day (at ca. 5 mm) rest on ventral surface of yolk sac (which is adhesive). Leave nests for short intervals by 4th day;[5] definitely rise from nest in 5–10 days (average 8 days) [6,10,23,44,86,104] at lengths of 5.92–6.31 mm (average 6.16 mm [6]). Time of rising from nest is correlated with temperature: at 13.0–18.3 C, 7.2 days; at 18.3–21.1 C, 6.7

days; at 21.1–24.0 C, 6.0 days.[59] Feeding begins concurrently with rising from nest (except at 15 C or below [19]), although the yolk is not yet fully absorbed.[86,127] Form schools shortly after hatching; after rising from nest remain in schools and move with current.[21,27,64] Specifically recorded at minimum temperature of 13.3 C.[20]

Juveniles—recorded from shallow, clear areas in lakes, ponds,[41,58] impoundments, spill pools,[48] and streams [24] over bottoms of mud or sand; typically associated with aquatic vegetation.[41,47,60,81] Remain in tight schools for 26 [6,127] to ca. 90 days,[3,10,124] with schools containing 40 [123]–10,000 individuals.[74] Schools disperse when fish reach average length of 32.5 mm,[6,127] but smallest solitary individuals ca 25.0 mm long.[10,15] Juveniles ca. 38.0–63.5 mm long sometimes mingle with schools of golden shiners.[4] Initially inshore [10,74] and near surface,[27] but move offshore to water 7.6–18.2 m deep in May, June, and July.[59] Rest on bottom at night.[58] Temperature range 6.0 [9]–39.0 C; [141] preferred temperature 29.3–32.0.[138] Maximum recorded salinity in nature 17.4 ppt; [52] but experimentally specimens 50–115 mm long showed lethal effect at salinities between 9.0 and 15.0 ppt [114] (although specimens 34–42 mm long survived 72 hours at 14.9 ppt [176]); maximum values in nature below experimental lethal values 7.3 [9]–7.6 ppt.[51] Specimens ca. 12.5–100.0 mm long recorded over pH range of 4.1–10.2.[140]

SPAWNING

Location: Lakes,[123] ponds,[49] sloughs,[127] swamps,[10] streams, and rivers; [137] in lakes typically in warm shallow bays [75] or shallow coves; in one lake mainly on level or gentle slope near mouths of intermittent streams; [59,123] populations in certain overcrowded eutrophic lakes may be nonreproductive.[92] Frequently (but not always) associated with various aquatic plants such as water milfoil,[123] coontail, water buttercup,[45] smartweed,[129] algae,[59] needlerush, water lily,[86,127] sedges, cattail,[3] and tamarisk; [59] also specifically on plant roots,[3,21,25,38] artificial nest of Spanish moss,[44] and dead leaves; [14] typically near edge of plant growth rather than in dense growth.[59] Recorded over substrates of gravel,[20,45,75,86,96,104] rocks,[59] boulders,[96] rubble,[59] sand,[14,41,45,75,86,115] marl,[5] and mud [38,45,49] (particularly where carp are present [108]); also over exposed talus slopes; when in areas of mud, silt, or detritus, usually dig to substrate of sand, rock, gravel, or roots.[59,115,123,127] Typically in shelter of rocks, ledges, submerged vegetation, stumps, logs,[3,56,96,112] or pilings; [115] rarely in open areas.[3] May spawn on bottom gradients of up to 52 degrees.[59] Recorded spawning depth, ca. 10.1 mm [3]–82.3 cm.[96]

Nests: Usually excavated in substrate,[123] although in some instances no nest is prepared [38] and eggs may be deposited directly on aquatic vegetation.[122] Nest diameter varies from 30.5 [10,129]–152.4 cm,[3] and depth from 15.0 [123]–43.2 mm.[3] The nests are round [43] or nearly so, and nest bottoms are typically comprised of stones, gravel,[10,43] sand,[123] or roots.[129] Nests are usually located between 1.22 and 6.40 m offshore. Adjacent nests may be confluent, may be spaced at intervals of 1.83–2.13 m,[3,56] or may be up to 9.14 m or more apart.[133] In rivers a maximum of 36.3 nest/km has been recorded.[137]

Season: In Florida, mid-November [107] through August (although ripe gonads have been reported in September [16]), peaks reported in February and March; [81] on Gulf coast (Alabama, Mississippi, and Texas), various intervals between January and June, but in Alabama apparently also in late fall; [15-17,16,42,90] in Oklahoma, early April to late August, but possibly discontinuous through midsummer; [1,88] in South Atlantic states (Georgia, South Carolina), nest as early as late February, eggs mid-March, spawning into August, but in one industrial cooling pond probably as early as December; [44,80,94,104] in northeastern states (New York, Rhode Island) various intervals between April and July; [14,50,112] in Ohio late May to mid-July, but mostly complete by mid-June; [27] in Michigan, Wisconsin, Iowa, and Minnesota various intervals from late April to early July; [5,6,45,47,75,117,127,131] in Illinois vacuolated eggs with peripheral oil globules in March, spawning late April [118] through July; [10] in Missouri, Arkansas, and Tennessee, April, May, and June; [30,88,102,137] in Arizona and Utah, late March to late June; [88,96,123] in California mostly mid-April to late May [76] with peak spawning in *M. salmoides floridanus* occurring about 2 weeks before beginning of spawning in *M. salmoides salmoides*; [115] in Canada, peak usually mid-June, spawning continued to August; [133] in Puerto Rico peak January through March; [22] in Spain end of May and June; [124] in the Philippines spawning completed by May 5.[46] Several spawning periods may occur during each spawning season: in Florida spawning is described as intermittent; [79] in Minnesota, Kramer and Smith described 3 separate spawning periods: [6] and, in Oklahoma, Summerfelt noted an average of 24 days between major spawning peaks.[61] In Florida, spawning is limited to "spring and summer" even in constant temperature (natural spring) environment; [56] under laboratory conditions off-season spawning can be induced by manipulating both temperature and photoperiod.[65]

Duration: Generally estimated at 6 [142]–10 weeks,[123] but in Florida up to 16 weeks; [107] in Missouri, 27–62 days with an average of 48 days; [137] in Arizona at least 75 days.[123]

Time: Some authors have stated that spawning takes place principally during daylight hours (morning and afternoon [44,104,131]), while others said usually at night,[86,125] or near dusk and dawn.[3,56] Spawning almost always occurs just before thunderstorms.[44,104]

Temperature: Range (based on actual spawning rather than nest building) 12.2 [59]–22.5 C or higher.[138] Typically, however, nest building occurs at 12.8–17.2 C and spawning at 16.7–22.5 C.[5,7,25,44,64,66,104,137] Bass transferred from 2.5–10.0 C water to 20 C water spawned in 6–39 days.[138] Peak activity at 15.5–18.3 C,[59,123] but average spawning temperature reported at 21.0 C.[61] In Puerto Rico, spawns in water which never cools below ca. 25.5 C.[138] Spawning generally occurs on a rising temperature,[112,137] but in Florida occurs when water cools to 15.6 C.[107]

Chemical characteristics: Salinity 5 ppt; pH, 5–10.[86]

Fecundity: 2000–145,000.[5,56,63,124] Fecundity increases with age, weight, and length.[62] Number of eggs per kg of fish 4400 [133]–176,400.[56]

EGGS

Location: Demersal,[133] attached to stones, roots, detritus, or other objects in the nest; [3,6,10,14] typically deposited in center of nest (JDH), but sometimes over whole bottom and lip of nest [192] (number of eggs/nest 5000–43,000 [56,127]),

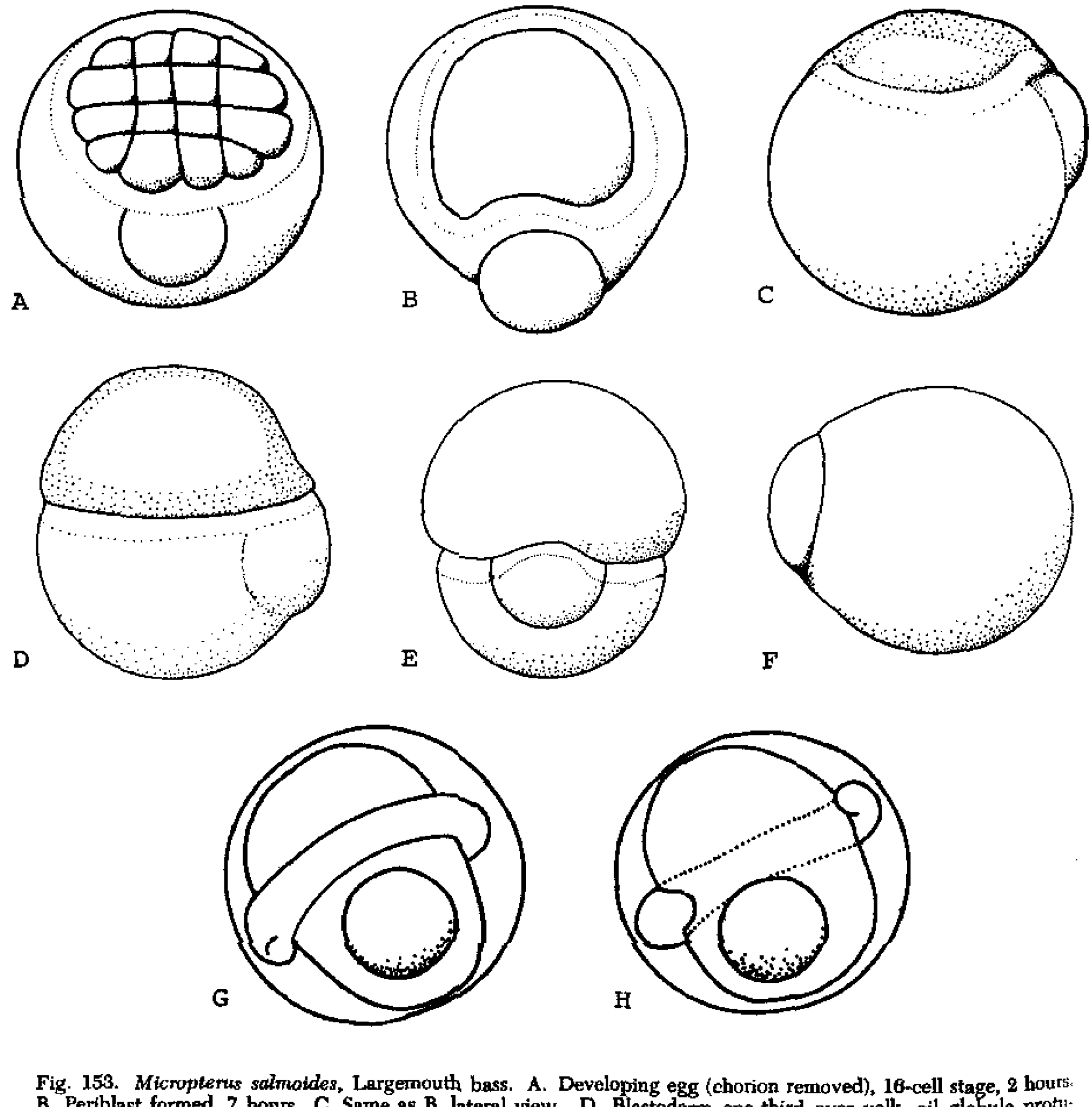

Fig. 153. *Micropterus salmoides*, Largemouth bass. A. Developing egg (chorion removed), 16-cell stage, 2 hours. B. Periblast formed, 7 hours. C. Same as B, lateral view. D. Blastoderm one-third over yolk, oil globule protuberant, 9 hours. E. Blastoderm beyond equator of egg, 10 hours. F. Yolk plug stage, 11 hours. G. Developing egg (chorion including), dorsal view of embryo. H. Developing embryo, ventral view. (*A-F, Carr, M. H., 1942: figs. 4–6, 10–12. G, H, Reighard, J., 1906: fig. 18, Joan Ellis, delineator.*)

Developing ovarian eggs: Initially with multiple oil globules, which gradually coalesce.[119]

Ripe, unfertilized eggs: Diameter, 0.75[86,120]–1.7 mm;[25] translucent; a single yellowish, coarsely granular oil globule 0.34–0.54 mm in diameter.[86,120]

Fertilized eggs: Spherical[56] or oval;[124] diameter of spherical eggs 1.4[2,56]–1.95 mm;[68] dimensions of oval eggs, 1.30–1.45×1.40–1.50 mm;[124] average diameter 1.74±0.116;[68] egg diameter increases with size of fish;[56,60] individual eggs light yellow,[123] yellow, orange,[56] or cream,[130] clear[123] (in fish maintained on live food, bright yellow; on artificial diet cream color[130]); egg masses with silvery luster[127] egg membrane adhesive[124,133] (at least initially), transparent, thin; egg capsule with delicate zona radiata; yolk transparent and with a single, large transparent, dark amber[3] or yellow oil globule;[123] occasionally several small auxiliary oil globules.[3]

EGG DEVELOPMENT

Development at 23–26 C (the Carr series):[3]

15 minutes	Eggs water-hardened, blastodisc forming, chorion no longer adhesive.
30 minutes	Blastodisc flattened.
35 minutes	Blastodisc swollen to form cup.
56 minutes	First cleavage furrow evident.
60 minutes	2-cell stage.
1 hour, 15 minutes	4-cell stage.
1 hour, 30 minutes	8-cell stage.
2 hours	16-cell stage, cells regular and even.
7 hours	Periblast evident.
8 hours	Blastopore, germ ring, and embryonic shield evident.
11 hours	Yolk plug stage (oil globule in yolk plug).
12 hours	Periblast thickened in region of posterior pole.
13 hours	A ridge evident in median line of embryonic shield.
14 hours	Head forming.
16 hours	Blastopore nearly closed; 4 somites formed; notochord evident.
24 hours	Olfactory bulbs, optic vesicles, and otic capsules formed or forming; 10 somites.
26 hours	Optic vesicles invaginated; constriction between mid- and hindbrain evident; 16 somites; Kupffer's vesicle formed.
30 hours	Tail free.
32 hours	Lens forming.
42 hours	Caudal region compressed laterally; finfold formed.
47 hours	Hatching.[3]

Development at unspecified temperature (the Johnston series):[13]

15 minutes	Blastodisc forming.
30 minutes	Blastodisc cap-like.
35–40 minutes	1st cleavage furrow evident.
55–60 minutes	2nd cleavage furrow evident.
75–80 minutes	3rd cleavage furrow evident.
120–160 minutes	32- to 64-cell stages.
6 hours	Peripheral periblast established.
9–12 hours	Blastoderm beyond equator of yolk, yolk plug established.
12–14 hours	Notochord evident.
14–16 hours	4 somites formed.
16–18 hours	Blastopore closed, tail bud formed, 7–8 somites.
18–22 hours	Fore-, mid-, and hindbrain evident, optic and olfactory placodes forming; otic capsule differentiated; pronephric ducts, Kupffer's vesicle formed; 10 somites.
22–26 hours	Lens forming, notochord vacuolated; 14–16 somites.
26–32 hours	Pronephic ducts closed anteriorly.
32–42 hours	Tail laterally compressed, 18–20 somites.
42 hours	Hatching, 33–36 myomeres (11+22–24).[13]

Comments on development: At ca. 40–42 hours after fertilization primordium of gas bladder and pneumatic duct developed; length of embryos 2.3–2.7 mm; rearing temperature unspecified.[106]

Incubation period at various temperatures:

At 10 C	13–21 days[125]
At mean of 17.7 C.	3–4 days[6]
At 18.0 C	55 hours[56]
	5.5 days[124]
At 18.9 C	5 days[86]
At 20.0 C	4.5 days[124]
At 21.1 C	5 days +[2]
At 22.2 C	2 days[86]
At 28.0 C	49 hours[56]
At 30.0 C	1.08 days[125]

Incubation at various temperature ranges:

At 13.0–15.5 C	5.4 days[59]
At 15.5–18.3 C	4.7 days[59]
At mean of 15.6–16.8 C	4 days[6]
At mean of 16.8–19.6 C	3 days[6]
At 18.3–24.0 C	5.1 days[59]
At 21.1–22.2 C	48 hours[126]
At 21.7–23.9 C	48 hours[23]

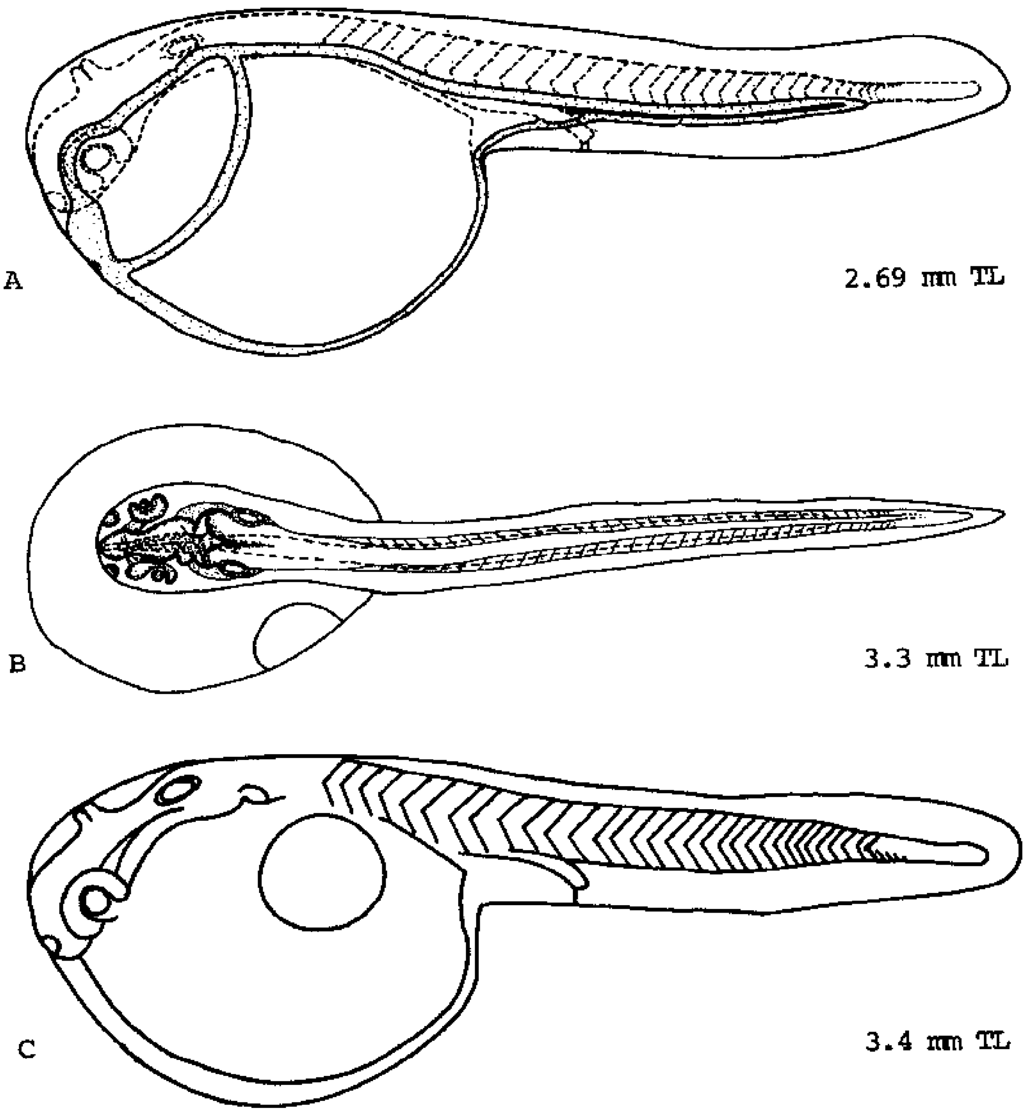

Fig. 154. *Micropterus salmoides*, Largemouth bass. A. Yolk-sac larva, 2.69 mm TL, 48 hours old. B. Yolk-sac larva, 3.3 mm TL, dorsal view. C. Yolk-sac larva, 3.4 mm TL, 47 hours old, 35 myomeres. (*A-C, Carr, M. H., 1942: figs. 23, 29, 31.*)

At 22.8–26.1 C 47–64 hours [3,6]

Notes on incubation: Eggs exposed to 4.4–7.2 C for 5–20 hours hatched successfully,[137] and viable eggs have been observed at 5.6 C; [123] development, however, is generally retarded below 15.6 C,[137] and, in one experiment, eggs incubated at 13–14 C all died.[124] Upper lethal temperature, 32.5 C or lower.[19] Optimum temperature for development, 19 [124]–20 C.[137] In one experiment a 25% loss of eggs was observed at 17–18 C, and a 50% loss at 15–16 C.[124] Eggs will hatch at dissolved oxygen levels as low as 1.0 mg/L, but survival drops sharply at levels below 2.0 and 2.8 mg/L at temperatures (respectively) of 15 and 25 C.[111] Movement causes premature hatching; thus eggs which had not been moved hatched in 64 hours while eggs from the same batch which had been moved hatched in 47 hours.[3]

YOLK-SAC LARVAE

Hatching length, 2.3 [124]–5.5 mm TL [56] (a report of hatching at lengths up to 12.7 mm [20] is questioned. JDH). Maximum length at end of stage ca. 7.7 mm TL.[1] Age at

A

B

C

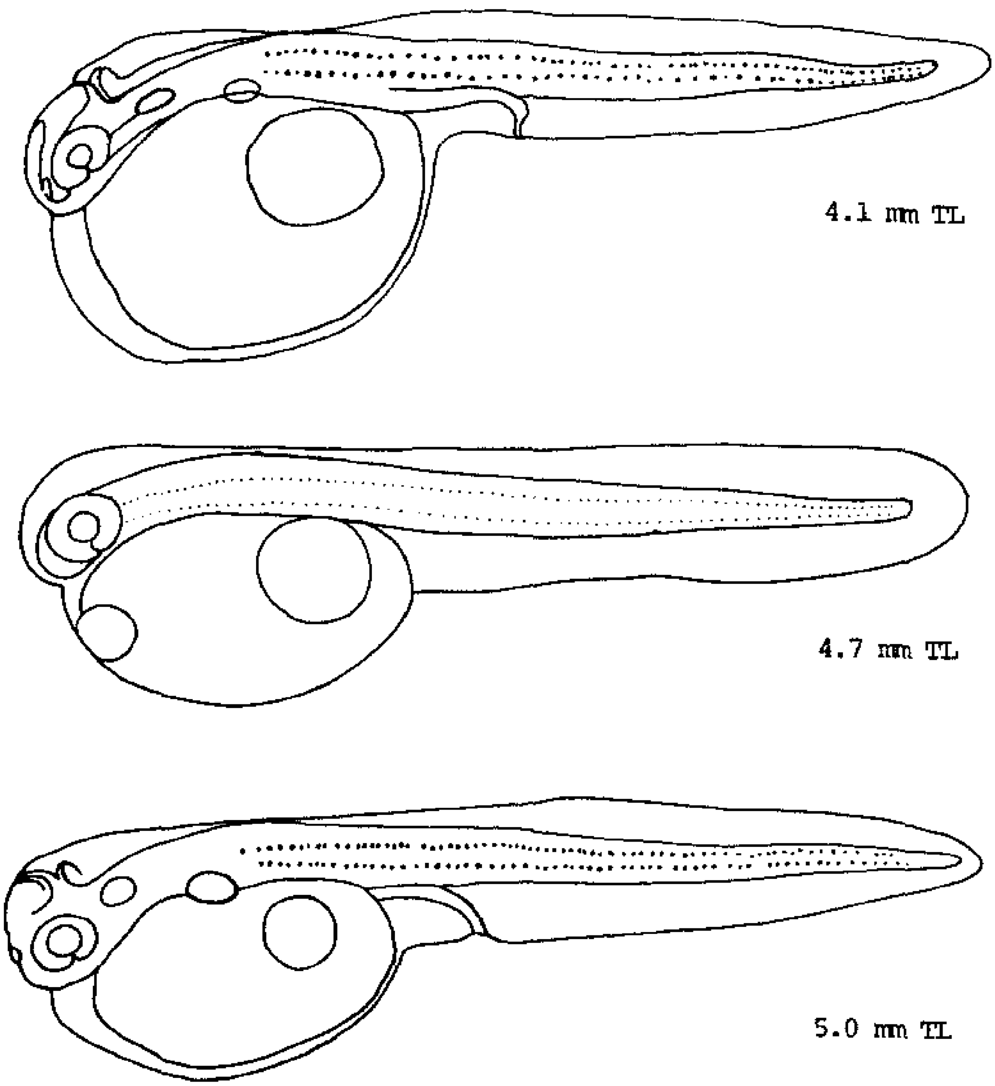

Fig. 155. *Micropterus salmoides*, Largemouth bass. A. Yolk-sac larva, 4.1 mm TL, 1 day old. B. Yolk-sac larva, 4.7 mm TL. C. Yolk-sac larva, 5.0 mm TL. (*A, C, Carr, M. H., 1942: fig. 32. B, Reighard, J., 1906: fig. 20, Tamiko Karr, delineator.*)

end of stage, 3[95]–15 days.

At 3.4 mm myomeres 11+24–25 (5 or 6 in tail tip), at 4.1 mm 11+23–24 (3 or 4 in tail tip), at 5.0 mm 11+19 (none in tail tip).[3]

Morphometrics (See table 2).

At hatching olfactory vesicles well defined, circular. Opercle first evident at 6.2 mm, entirely over gills 7.2 mm. At hatching choroid fissure wide, closed at 5.0 mm,[3] but indicated by faint line at lengths up to 7.0 mm.[1]

Upper jaw developing at 6.5 mm; lower jaw developing at 5.0 *mm*, movable at 6.2 mm. Mouth functional at 6.5–7.2 mm.[3]

Table 2. Measurements of four yolk-sac larvae of *Micropterus salmoides*.[3]

Length	Snout-vent length	Greatest depth	Eye diameter
3.4 mm TL	2.1 mm	1.4 mm	1.26 mm
4.1 mm TL	2.12 mm		0.28 mm
6.2 mm TL	2.7 mm	1.4 mm	0.4 mm
6.5 mm TL	3.0 mm	1.3 mm	0.6 mm

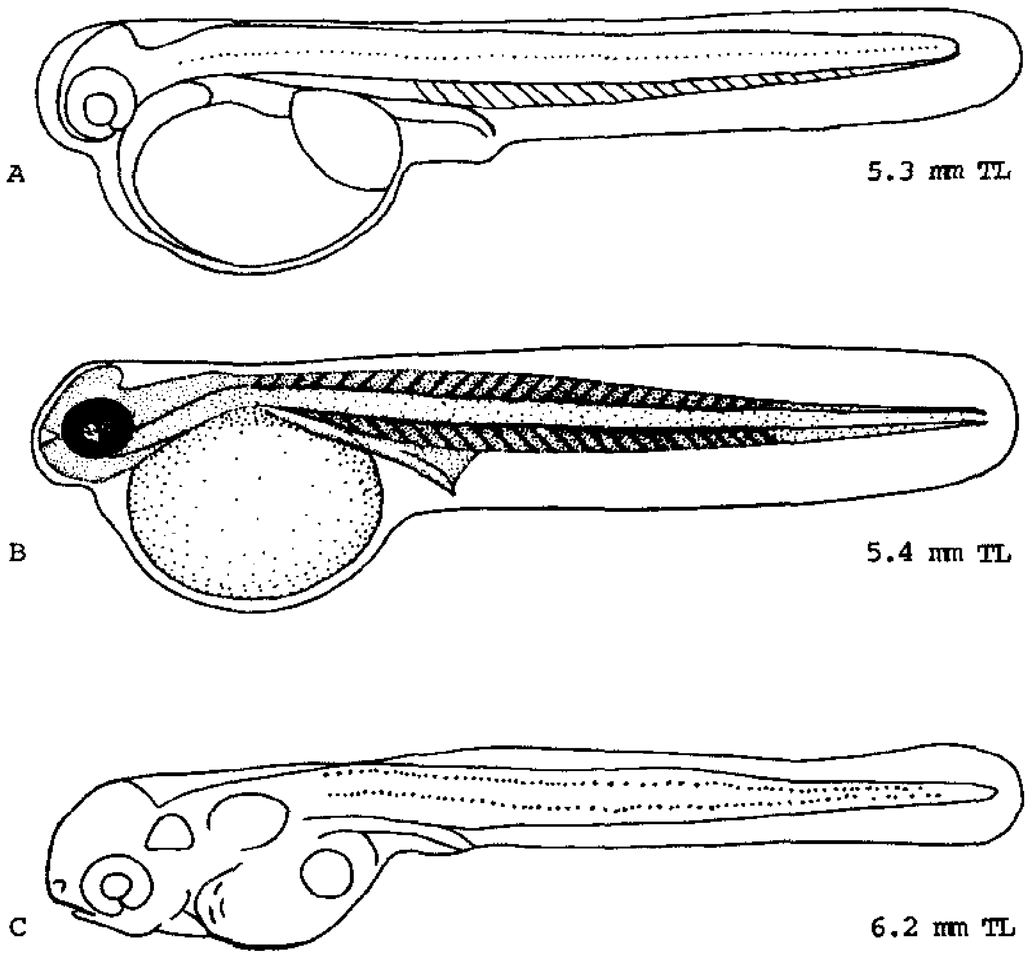

Fig. 156. *Micropterus salmoides*, Largemouth bass. A. Yolk-sac larva, 5.3 mm TL, 2 days old. B. Yolk-sac larva, 5.4 mm TL. C. Yolk-sac larva, 6.2 mm TL, 4 days old. (*A, Reighard, J., 1906: fig. 21, Tamiko Karr, delineator. B, Meyer, F. M., 1970: fig. 2. C, Carr, M. H., 1942: fig. 34.*)

Dorsal and anal mesenchyme evident at 7.0 mm TL, incipient rays at 7.7 mm.[1] Caudal development first evident at 6.5–7.2 mm TL (mesenchyme on 8th day, rays on 10th day). Pectorals evident as slight ridges at hatching (3.4 mm), rounded and enlarged at 4.1 mm (1 day), movable but rayless at 6.2 mm (4 days), rays evident at 6.5–7.2 mm (6 days).[3] Urostyle oblique at 7.0 mm TL.[1]

At hatching alimentary canal not open; cloaca and pronephric ducts formed. Heart a simple, vertically oriented tube anterior to head at hatching, pericardial cavity not formed; by 3rd day 3 aortic arches evident; by the 4th day heart in horizontal rather than vertical position.[3] Pneumatic duct with slight lumen continuous with gut at hatching.[106] Gas bladder first evident in some individuals at 5.0 mm,[3] in others formed and partially filled at 4.0 mm (1–2 days after hatching),[106] completely filled by 6th day (6.5–7.2 mm).[3] Lumen of pneumatic duct reduced, duct apparently atrophied at 6.0 mm (4–6 days); at 6.0–7.0 mm functional connection of pneumatic duct with gut completely lost.[106]

Pigmentation: Hatchlings up to 4.75 mm long without pigment.[3,55] Eye pigment well-developed in some individuals at 5.0 mm [3] (at age of 1 [23]–3 days [3]), just developing in others at 5.4 mm,[2] and not fully developed in others at 6.2 mm.[1] Eye distinctly iridescent at 6.2–6.3 mm.[3,55] At 5.0 mm chromatophores above and below gas bladder.[106] At 5.0–6.2 mm melanophores developing on head, dorsal and lateral lines and yolk.[3] At ca. 5.6 mm a few melanophores along junction of body and yolk sac and on yolk sac.[55] At 6.2 mm melanophores generally more numerous.[3] At 7.0 mm pigment well-developed on forward part of abdomen and gas bladder.[1]

At 8–9 days yellow pigment, more abundant than black, on whole body except yolk and lower half of first 2/3

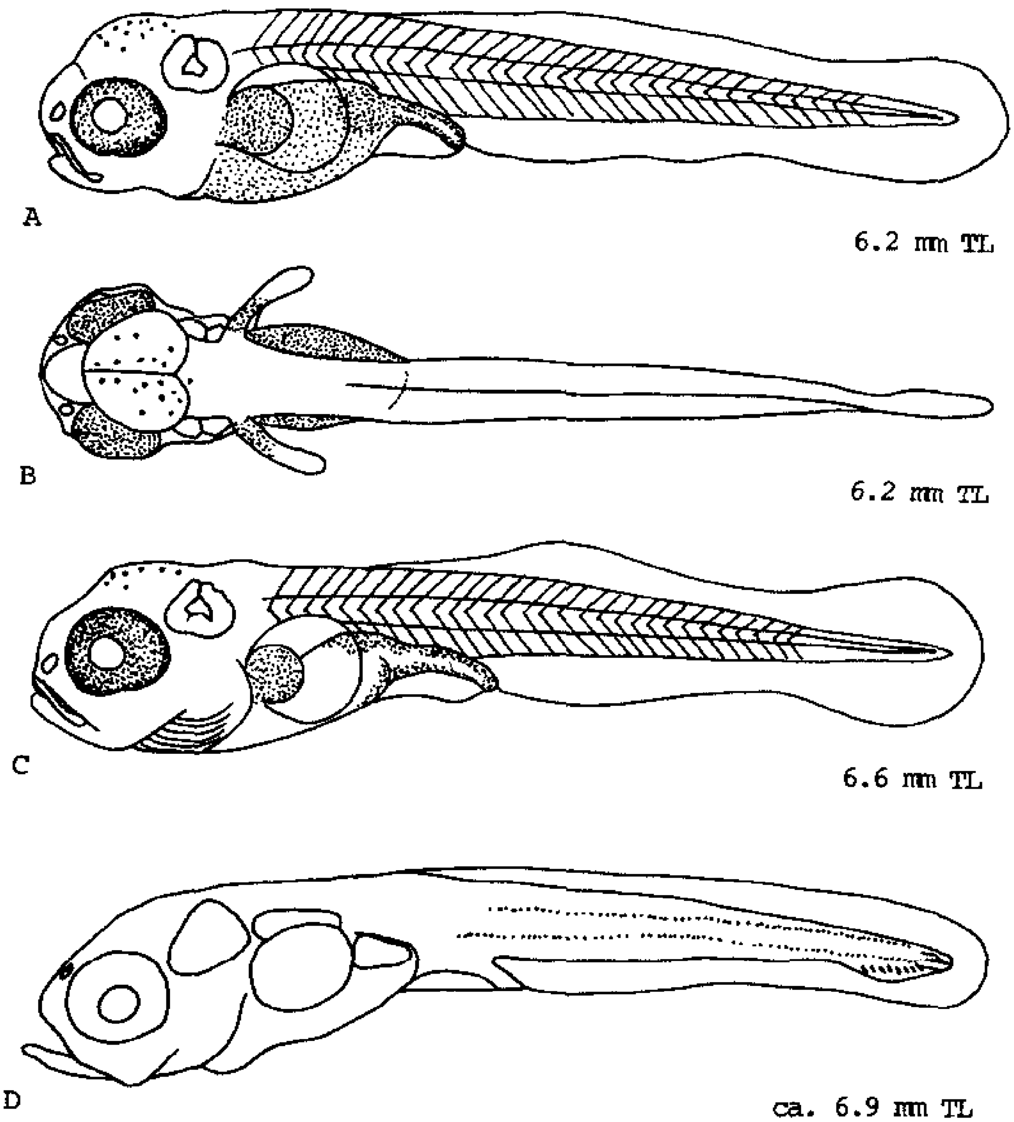

Fig. 157. *Micropterus salmoides*, Largemouth bass. A. Larva, 6.2 mm TL. B. Dorsal view of A. C. Larva, 6.6 mm TL. D. Larva, ca. 6.9 mm TL, 7 days old. (*A-C, C. A., 1969: fig. 13, Joan Ellis, delineator. D, Carr, M. H., 1942: fig. 36.*)

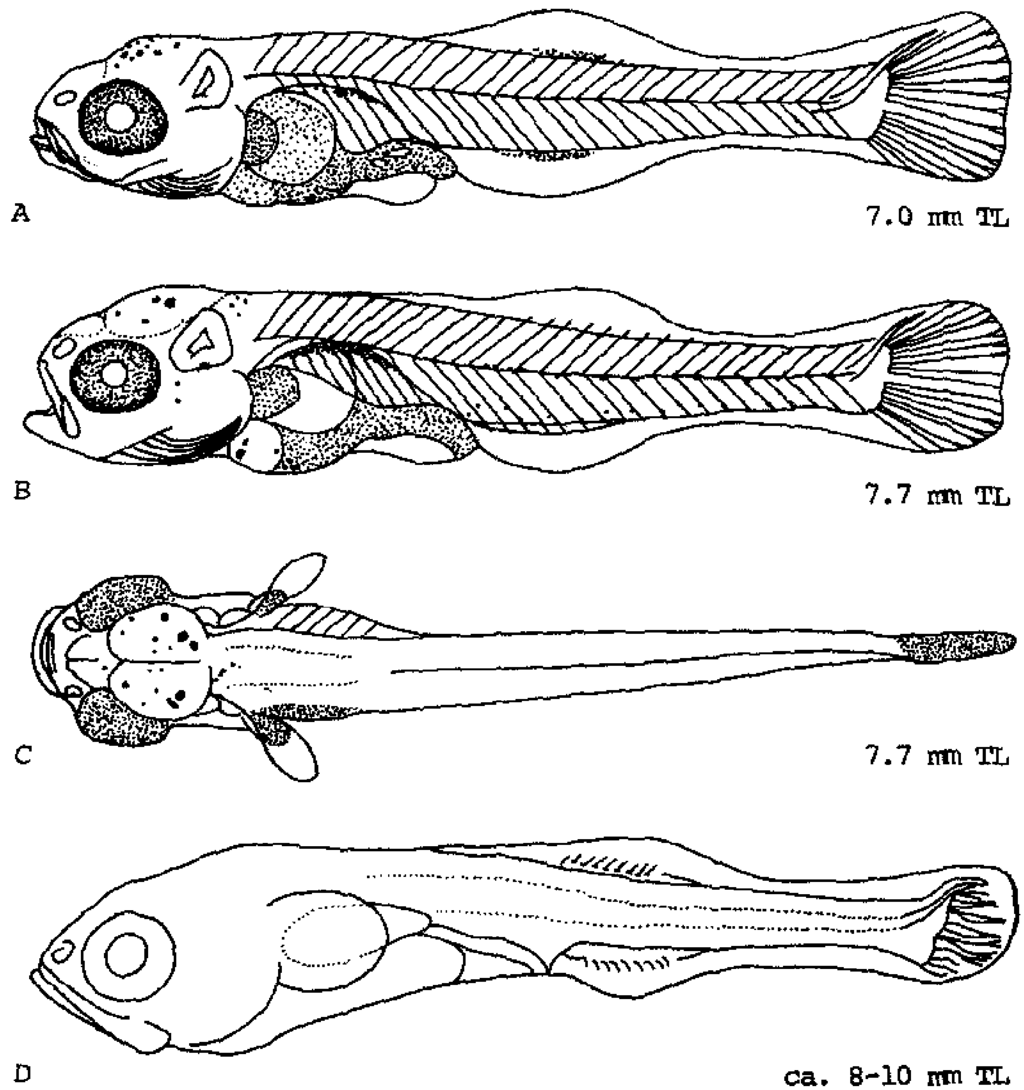

Fig. 158. Micropterus salmoides, Largemouth bass. A. Yolk-sac larva, 7.0 mm TL. B. Yolk-sac larva, 7.7 mm TL. C. Dorsal view of B. D. Larva, ca. 8–10 mm TL, 15 days old. (*A-C, Taber, C. A., 1969: fig. 13. D, Carr, M. H., 1942: fig. 38.*)

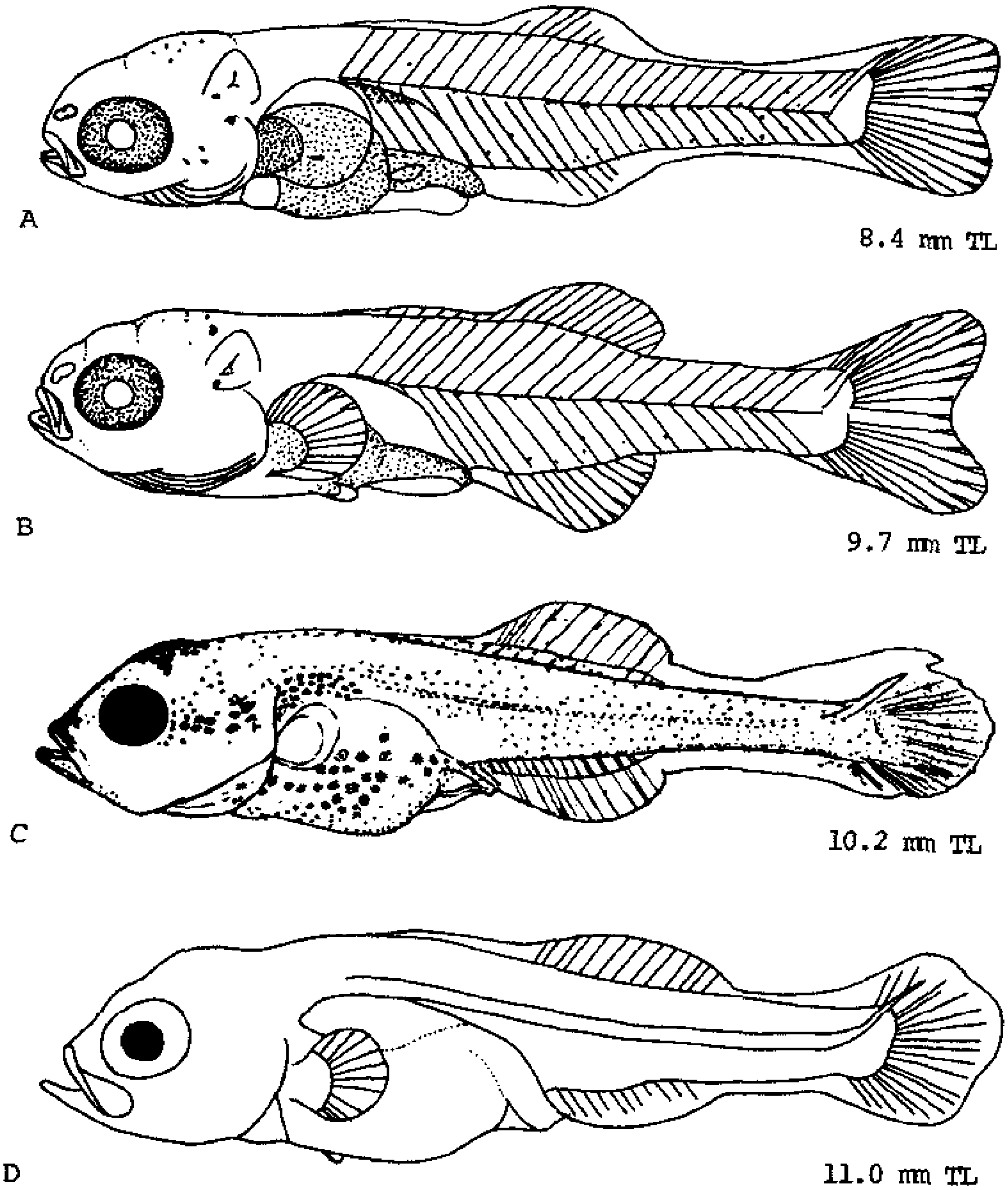

Fig. 159. *Micropterus salmoides*, Largemouth bass. A. Larva, 8.4 mm TL. B. Larva, 9.7 mm TL (note presence of pelvic bud). C. Larva, 10.2 mm TL. D. Larva, 11.0 mm TL. (*A, B, Taber, C. A., 1969: fig. 13, Tamiko Karr, delineator. C, Meyer, F. A., 1970: fig. 2. D, Kramer, R. H., and L. L. Smith, Jr., fig. 2, Joan Ellis, delineator.*)

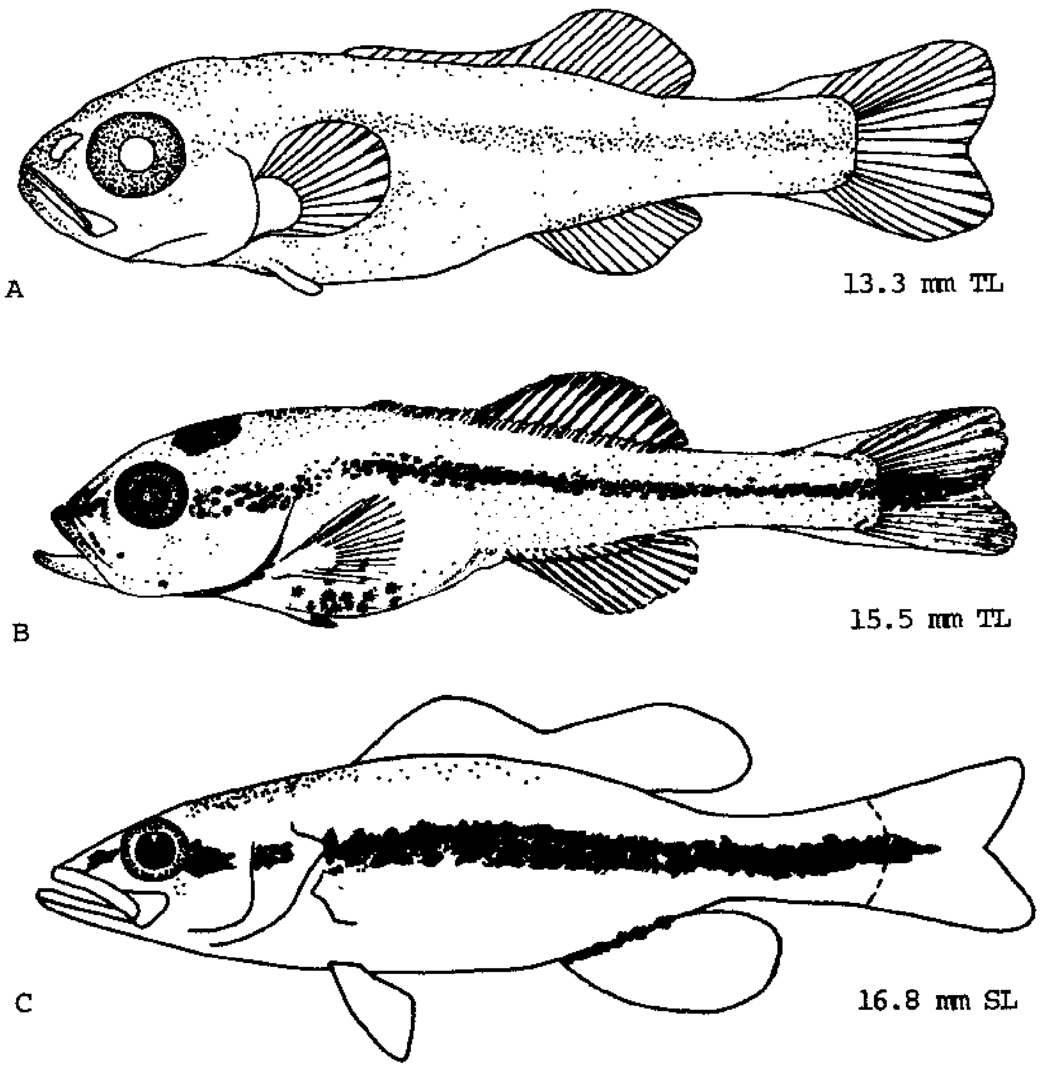

Fig. 160. *Micropterus salmoides*, Largemouth bass. A. Larva, 13.3 mm TL. B. Larva, 15.5 mm TL. C. Juvenile, 16.8 mm TL. (*A, Taber, C. A., 1969: fig. 13, Joan Ellis, delineator. B, Meyer, F. A., 1970: fig. 2. C, Ramsey, J. S., and R. O. Smitherman, 1972: fig. 1, Joan Ellis, delineator.*)

of sides of tail. Black pigment typically diffuse, scattered, lacking on lower parts of head.[56]

LARVAE

Size range, 6.0 mm TL [131]–16.8 mm SL.[70]

Preanal finfold still evident at 9.7 mm TL.[1] Incipient dorsal and anal rays in some specimens as large as 10.2 mm, dorsal spines at 15.5 mm; caudal rays first evident at 7.0–7.2 mm, complete at 8.0 mm; caudal homocercal at ca. 11.0 mm. Pectorals with rays forming dorsally at 9.7 mm in some individuals,[1] rays entirely lacking in others at 10.2 mm. Length at appearance of pelvics apparently variable: 9.7 [1]–15.5 mm.[2]

At 10.0 mm rudiment of pneumatic duct evident as vesicle in posterior part of air bladder.[106]

Pigmentation: At 7.7 mm additional pigment developed ventrally between anus and tail and in faint row on mid-lateral region of posterior half of body; dorsal head pigment in two poorly-defined bilateral blotches.[1] At 10.2 mm sparse pigment over body with concentrations over head, behind eye, above anterior part of gut, on lower half of gut, in an indefinite lateral band, and along caudal rays.[2] At 13.3 mm TL pigment over head, snout,

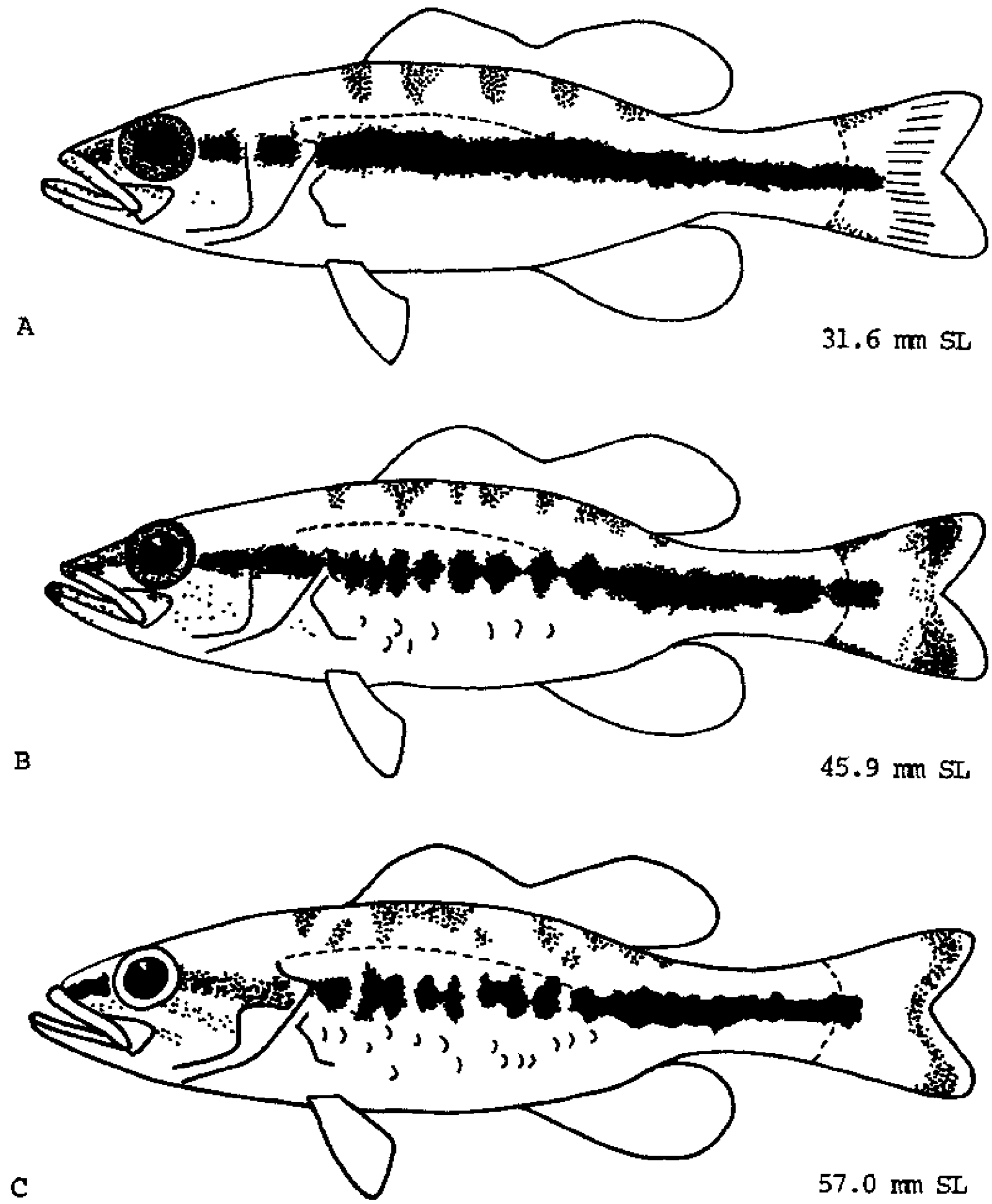

Fig. 161. *Micropterus salmoides*, Largemouth bass. A. Juvenile, 31.6 mm SL. B. Juvenile, 45.9 mm SL. C. Juvenile, 57.0 mm SL. (*A-C, Ramsey, J. S., and R. O. Smitherman, 1972: fig. 1, Joan Ellis, delineator.*)

and tip of lower jaw; a few spots along base of dorsal fin; scattered pigment over abdomen and along anal fin; a conspicuous rather broad band of pigment from behind eye to caudal base spreading dorsally and ventrally at end of caudal peduncle; few chromatophores along caudal rays.[1] At 15.5 mm TL lateral band well-developed, extending from caudal base forward to snout; few large stellate chromatophores ventrally on body; a large blotch of pigment on top of head.[2] In specimens 15 days old, yellow pigment above lateral line, abdominal wall iridescent.[3]

JUVENILES

Minimum size described, 16.8 mm SL.[70]

Pyloric caeca, 20–33 at 16–30 mm.[87]

At 75.0 mm TL, HL 28.0, greatest depth 19.5 mm, eye diameter 4.8 mm, body elongate, lower jaw projecting, gape to back to eye.[8]

Scales first evident at age of one month; [39] at 16.8 mm SL, 5 scales on posterior part of lateral line.[70]

Sexes distinguishable microscopically at 30 mm, grossly at 40 mm.[13]

Pyloric caeca countable, branched at 16.0–30.0 mm.[87]

Pigmentation: In "young" of unspecified length black dorsal spotting better defined than in adult.[9] Lateral stripe conspicuous, wide, and essentially uninterrupted in unscaled fish, persisting under blotched scale pattern in later stages; [70] sharply defined on caudal peduncle; [32] generally fainter in large juveniles, especially those from turbid water.[70] Caudal fin initially uniform in small juveniles; [37] a distinct caudal spot, elongated posteriorly, in fish up to 60 mm long; caudal submarginal band never very intense, usually indistinct anteriad; caudal lobes occasionally with whitish iridescence.[70] "Young" also described as very pale green [133] or with silvery sheen.[9]

At 35 mm caudal submarginal band just forming, at 40 mm and over this band well-developed.[70] At 50 mm (but apparently in only some specimens of this size) lateral stripe broken into series of spots, and a row of similar spots along each side of back.[55] At 75 mm slightly greenish above, silvery below; lateral band broad, dark, extended from behind eye to caudal fin; three oblique stripes across cheek and opercle behind eye; small melanophores on dorsal and lateral surfaces, these darker and more numerous above lateral line; belly white; all fins sprinkled with chromatophores.[9]

AGE AND SIZE AT MATURITY

Mature at a minimum of 8 months in Cuba,[106] 9 months in Florida; [117] otherwise 1 year in southern states [28,84,86,13] to 2–4 years in northern states and Canada.[86,101,118,133]

Minimum size at maturity, ca. 140 mm in Cuba; [105] females reported with developing eggs at 199 mm SL in Arizona; [123] males guarding nest at estimated length of 200 mm in Florida; [3] otherwise mature at ca. 254 mm.[5,38,97]

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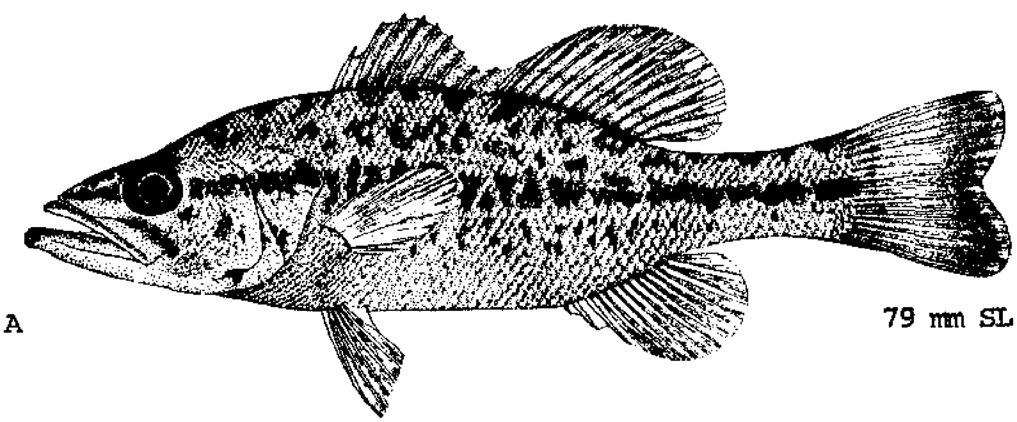
A



79 mm SL

Fig. 162. *Micropterus salmoides*, Largemouth bass. A. Juvenile, 79 mm SL. *(A, Trautman, M. B., 1957: fig. 131.)*

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Pomoxis annularis Rafinesque, White crappie

ADULTS

D. IV to VIII [6] (usually VI [19]), 13–15; [17] A. V [12] to VII, 16 [41]–19; [12] V. I, 5; P. usually 13; [41] scales on cheek, 4–6,[12] in lateral line, 33 [41]–48; [17] preanal vertebrae, 15; postanal vertebrae, 18; [19,26] total vertebrae, 30–32; [41] gill rakers lower limb first arch, 21 [18]–24, upper limb, 6–8; branchiostegal rays, 7; pyloric caeca, usually 10.[41]

Depth 23.8–29.0 percent TL,[41] more than 2.4 times in SL; [20] head 25.3–27.9 percent TL; eye 24.5–29.4 percent HL.[41] Dorsal fin base less than distance from dorsal fin origin to posterior orbital rim.[15]

Body compressed; [2] preopercular margin with small serrations at lower posterior angle; [18] mouth moderately oblique; [20] maxillary very long, reaching posterior margin of eye; [41] teeth present on vomer, palatine, and ectopterygoids; gill rakers long, slender. Dorsal and anal fins about equal; spinous and soft portions of the dorsal fin broadly connected.[2]

Pigmentation: Olive or brownish green above with bluish, greenish, or silvery reflections,[6] sides olive green,[2] silver olive, or silver-white, with 5 to 10 chain-like double bands of dusky or black, these most distinct on upper sides; [6,12] a vague black spot near edge of opercle; [41] venter silvery or milk white. Dorsal and caudal fins vermiculated with green, and sometimes with ocelli; anal fin described as pale, nearly plain, silver-white; also as vermiculated with green, and sometimes with darker colors and/or ocelli; [6,12] pelvic and pectoral fins plain, translucent; [18] pectoral fins transparent, amber to yellow, and lacking black. Eye yellow, green,[41] or brownish.[34] Large adults from turbid waters may almost lack lateral markings.[6] Breeding males much darker than females, with darkest color on sides of head, lower jaw, breast, and, to lesser extent, sides of body.[2,24,29]

Maximum length: 533 mm.[41]

DISTRIBUTION AND ECOLOGY

Range: From Nebraska and Minnesota through parts of Wisconsin and Michigan to Lake Huron and the Lake Erie basin in Ontario; also northern parts of Ontario drainage and possibly the St. Lawrence River; south through Mississippi Valley to Texas and other Gulf states and north along Atlantic slope to North Carolina.[2,9,15,16,19] Introduced northward on Atlantic coast at least to Delaware River,[40] in western parts of United States,[19] and in Connecticut.[41]

Area distribution: Introduced in Chesapeake Bay area in 1894,[22] and now known to occur in Virginia [4] and Maryland tributaries of Chesapeake Bay north to Susquehanna River; [18] also reported from Delaware River.[40]

Habitat and movements: Adults—a schooling species [2,36] found in ponds, lakes, impoundments, sloughs, bayous, oxbows, rivers, and moderate or large sluggish pools or low gradient streams, over bottoms of mud, clay, sand, or gravel; frequently found in association with aquatic vegetation or congregated around submerged brush, logs, stumps, and tree roots; often in turbid water.[6,12,17,19,21,30,31,34] Maximum depth, 15.2 m [14] (reported at maximum depths in January, at least depths in April [38]). Maximum reported salinity, 6.0 ppt, but also reported in water in which salinity varied from 3.8 to 14.9 ppt. Maximum reported temperature, 29 C.[23] Move inshore during spawning season; [2] otherwise tend to stay in limited area although one specimen was recovered 38 km from point of release; [38] in lakes movements of 0.2–2.0 km have been recorded over a time span of 6 to 41 days.[29]

Larvae—initially may become attached head first to masses of hatched eggs; [2] just after hatching remain in nest and guarded by male parent; [39] at sizes up to 4.5 mm abundant in shallow waters of spawning area.[1] Leave nest 51 to 162 hours (average 95 hours) after start of hatching at lengths of 4.1–4.6 mm (and no longer guarded by male parent); [39] initially concentrated near surface at night, distributed rather evenly throughout water column in daylight; at 5–10 mm evenly distributed at night, most abundant at bottom in daylight.[1]

Juveniles—recorded along beaches in Delaware River; [3] at 10.5 mm and longer most abundant at bottom, and showing no diurnal variation in depth distribution; [1] young recorded as swarming "in great numbers" in overflow ponds and bayous where they sometimes perish when these waters dry up.[27,37] Maximum reported salinity, less than 2 ppt. Reported temperature range, 1.2–19.5 C.[3]

SPAWNING

Location: Spawn in colonies,[13,39] but with nest sometimes separated by 61–122 cm, in sometimes turbid water 51 mm [2,22] to 6.1 m deep [24] and 0.6–9.1 m from shore over bottoms of gravel, rocks, boulders, sand, clay, and mud; also sometimes over submerged brush, trees, and roots, among beds of aquatic plants such as *Eleodea*, and under overhanging banks, cliffs, and ledges.[2,12,13,22,24,36] In artificial habitats over hay mats, clumps of sod,[39] concrete, cow manure, and straw.[24] Generally seem to prefer some protective object or bottom vegetation, but will also spawn successfully on barren substrate.[39] Sometimes spawn in bluegill nests.[25] Some nests exposed to full

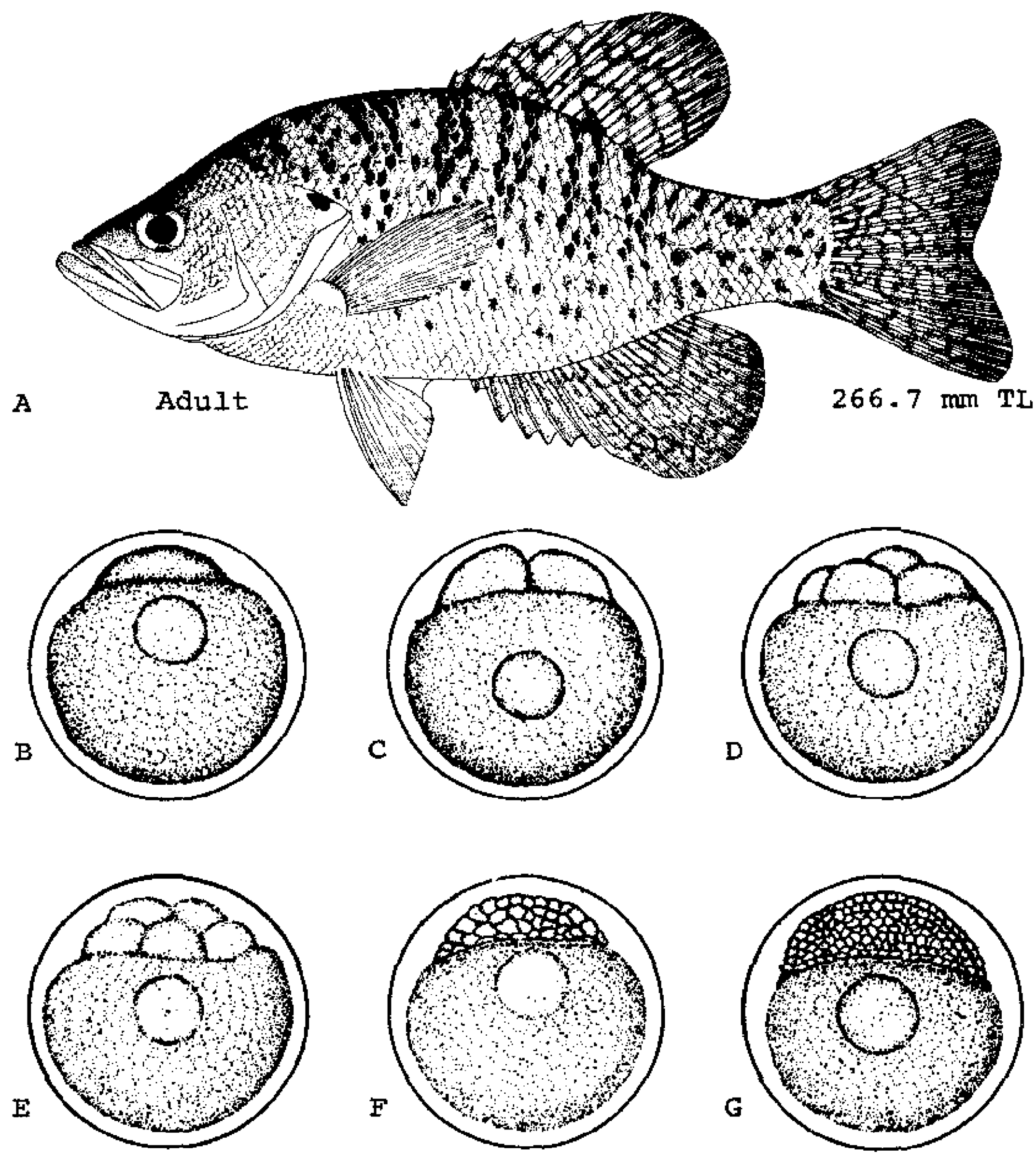

Fig. 163. *Pomoxis annularis*, White crappie. A. Adult, 266.7 mm TL. B-G. Developmental series based on specimens from Ohio. B. Blastodisc formed, 5 minutes after fertilization. C. 2-cell stage, 50 minutes. D. 4-cell stage, 55 minutes. E. 5- to 8-cell stage, 1 hour. F. Morula; 1 hour, 15 minutes. G. Late morula; 2 hours, 15 minutes. (*A, Trautman, M. B., 1957: fig. 126. B-G, Morgan, G. D., 1954: figs. 3A-3F.*)

sunlight, others partly shaded.[13]

Nests: Variable, sometimes no indication of excavated nest,[22] sometimes excavated, but not sufficiently to make well defined depression,[13,38] and sometimes sufficiently excavated to expose underlying sand; [22] nest diameter 12.5–37.5 cm,[13] average 30 mm.[22] Nests sometimes fringed with *Chara*,[38] and largest nests sometimes covered with algae and tree leaves.[13]

Season: Spawning possibly occurs as early as mid-March[1] to late July [2,10] with northern populations spawning somewhat later than southern populations. In Texas and Oklahoma spawning colors [24] and, possibly, spawning in mid-March and spawning continued to mid-June[1] with peak in late April and early May; [24] in South Carolina, gravid fish first week of April; [11] in Ohio late March or early April to July 20; [2,16] in Colorado, mid-July; [12] in

Illinois, male breeding colors evident in April,[29] spawning May 13 to June 10 or possibly later[13] (in another study ripe males May 16 to June 24, ripe females May 6 to July 13), spawning peak late May to early June;[29] in South Dakota, May 14 to June 15.

Time: Occurs from 0850–1600 hours, but mostly before 1200 hours.[39] Breder reported crappies, putatively this species, spawning at night under laboratory conditions.[8]

Temperature: Spawning initiated at 15.8 C.[24,36] Temperature fluctuation during spawning period 10.6–26.9 C,[2] but most spawning apparently at average daily temperatures of 16–20 C.[39]

Fecundity: 970[24]–325,677,[2] with averages reported at 7000[36] and 53,000.[31] A 190 mm TL female produced 15,000 eggs.[12] Cooper found that development of ova from oogonia is a continuous process with no distinct demarcation of developmental stages;[35] consequently not all eggs are spawned at once, and ovulation continues over a long period.[2]

EGGS

Location: Demersal, attached to grass[2] and grass roots,[22] dead grass blades hanging down in water,[29] tree leaves[22] and roots,[29] and algae;[6] sometimes in open nest directly on substrate.[2] Occasionally attached considerably off bottom as, for example, within ca. 50 mm of surface.[29] In artificial environments, on sides and screens of spawning pens, tree limbs, and sod clumps. Sometimes found in

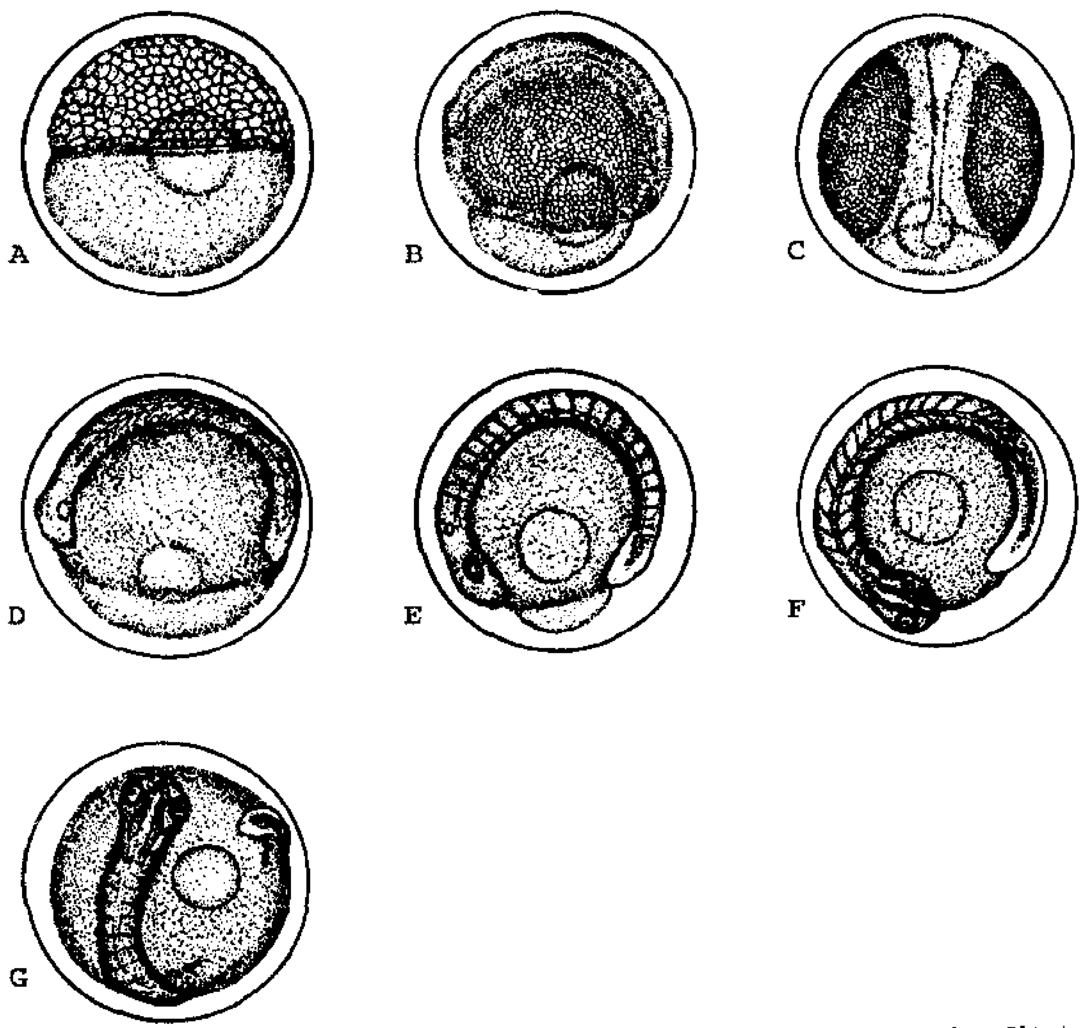

Fig. 164. ***Pomoxis annularis***, White crappie. A-G. Developmental series based on specimens from Ohio (continued). A. Blastoderm to equator of egg, 3 hours, 15 minutes. B. Blastoderm below equator of egg, embryo distinct; 5 hours, 15 minutes. C. Same as B, dorsal view. D. Somites forming, 9 hours. E. 20–22 somites, blastopore not yet closed; 16 hours, 15 minutes. F. 21 hours, 15 minutes. G. Tail free, heart beat established, 23 hours. (A-G, *Morgan, G. D.*, 1954: *figs.* 3G-3M.)

clumps of 3 or more, and frequently covered with detritus.[39]

Mature, unfertilized eggs: Diameter 0.82–0.90 mm, with granular yolk and single large oil globule.[2]

Fertilized eggs: Diameter 0.82–0.92 mm, average 0.89 mm; [23,24] colorless; [41] egg capsule adhesive, initially highly elastic, at hatching dissolved into a sticky mass; yolk with a single, large oil globule; perivitelline space ca. 1/7 yolk diameter.[2]

EGG DEVELOPMENT

Development at 21.1–22.2 C: [2]

20 minutes	blastodisc cap-like.
50 minutes	2-cell stage.
55 minutes	4-cell stage.
1 hour	8-cell stage.
1 hour, 15 minutes	early morula.
2 hours, 15 minutes	late morula.
3 hours, 15 minutes	blastoderm to equator.
5 hours, 15 minutes	blastoderm below equator, embryo distinct.
9 hours	10–12 somites, brain evident, optic evaginations present.
16 hours, 15 minutes	20–22 somites, brain in three parts, optic and nasal capsules forming.
21 hours, 15 minutes	23–25 somites, embryo not completely around yolk.
23 hours	heartbeat, tail movement established.
27 hours, 30 minutes	hatching.[2]

Incubation period: At various temperatures 24 [2] to 103 hours; at average of 14.4 C, begin hatching at 93 hours; at 18.3–19.4 C, begin hatching at 43–51 hours; [39] at 21.1–22.0 C, 24–27.5 hours; [2] at 22.8 C, 42 hours. Time period between beginning and end of hatching period, 20 hours.[39]

YOLK-SAC LARVAE

Morgan reported hatching lengths of 1.22–1.98 mm,[2] while Siefert found a minimum total length at hatching of 2.54 mm.[33] These differences probably reflect premature or delayed hatching (JDH). Length at end of stage 4.0 [2]–4.6 mm.[39]

Myomeres, at 3.72 mm, 10+19; [7] at 3.9 mm, 12+19 [2] (counts from drawings, JDH). In smallest hatchlings body coiled around yolk; straightened at 1.75 mm. Yolk distinctly granular throughout stage. Jaws not evident in smallest specimens; present but not movable at 3.7 mm; movable at 3.9 mm (4 days, 10 hours). Gill clefts evident at 3.0 mm; gill filaments at 3.9 mm. Choroid fissure evident throughout stage. Otoliths formed at 3.0 mm.[2] Finfold constricted about and below region of caudal peduncle in a specimen 3.72 mm long; [7] not so in another 3.9 mm long; [2] pectoral buds absent in specimens less than 3.0 mm long, rounded but rayless at 3.72 mm; [7] with rays at 3.9 mm; caudal fin rays first evident at 3.7 mm. Gut beginning to fold in region of yolk sac at 3.9 mm. Auricle, ventricle, and ventral aorta clearly defined at 3.0 mm.[2] Gas bladder evident at 3.72 [7]–3.9 mm (4 days, 10 hours).[2]

Pigmentation: Eye apparently not pigmented at hatching,[2] and possibly not throughout stage (JDH). Pigment evident on gas bladder at 3.72 mm,[7] and ventrally between anus and region of caudal peduncle at 3.9 mm.[2]

LARVAE

Size range specimens described, 4.0 [2]–20.0 mm.

Total myomeres, at 6.0–16.0, 30–31; at 4.0–16.5 mm, mean 30.1 (derived), modes 29–31.[33] Preanal myomeres, at 4.0–9.3 mm, 9–13 [1,2] (based on counts from drawings, JDH); at 4.0–16.0 mm, mean 11.7 (derived), modes 10–13, gradually increasing with size.[33] Postanal myomeres, at 4.0–9.3 mm, 20–23 [1,2] (based on counts from drawings, JDH); at 5.0–6.49 mm, 19 or less; at 4.0–16.0 mm, mean 18.6 (derived), modes 17–20.[33]

Nostrils still undivided at end of stage. Remnant of preanal finfold apparently retained to at least 13.5 mm.[2] Mesenchyme in region of future dorsal and anal fins at 9.3 mm; [1] incipient rays in dorsal and anal fins at 11.0–11.5 mm, spines at 13.5–14.0 mm; sixth dorsal spine formed at 20.0 mm [33] (Morgan's comment that incipient rays are evident in the dorsal and anal fins in 10 days at 4.2 mm [2] is questioned, JDH); minimum length at appearance of first incipient caudal rays variously indicated as 4.0 mm or less,[2] 8.3 mm,[1] and 11.0–11.5 mm; [33] pectoral fin rays indicated by Morgan at 4.0 mm or less; [2] otherwise not well-developed until 13.5 mm; pelvic buds evident at 13.5 mm. Urostyle very slightly flexed at 8.3 mm, completely flexed at 11.2 mm.[1] Gut well coiled at 4.0 mm.[2]

Pigmentation: Body transparent at time of departure from nest (4.1–4.6 mm).[41] Pigment patterns apparently vary geographically (JDH). In specimens from Ohio 4.0–6.0 mm long gas bladder with large, widely and evenly spaced chromatophores; a heavy row of chromatophores, apparently one per myomere, along ventral surface between anus and tip of tail; a similar, less pronounced row just beneath notochord from region of gas bladder to point approximately one-fourth TL from tip of tail; eye apparently unpigmented.[2] In specimens from Oklahoma, at 4.3 mm gas bladder densely pig-

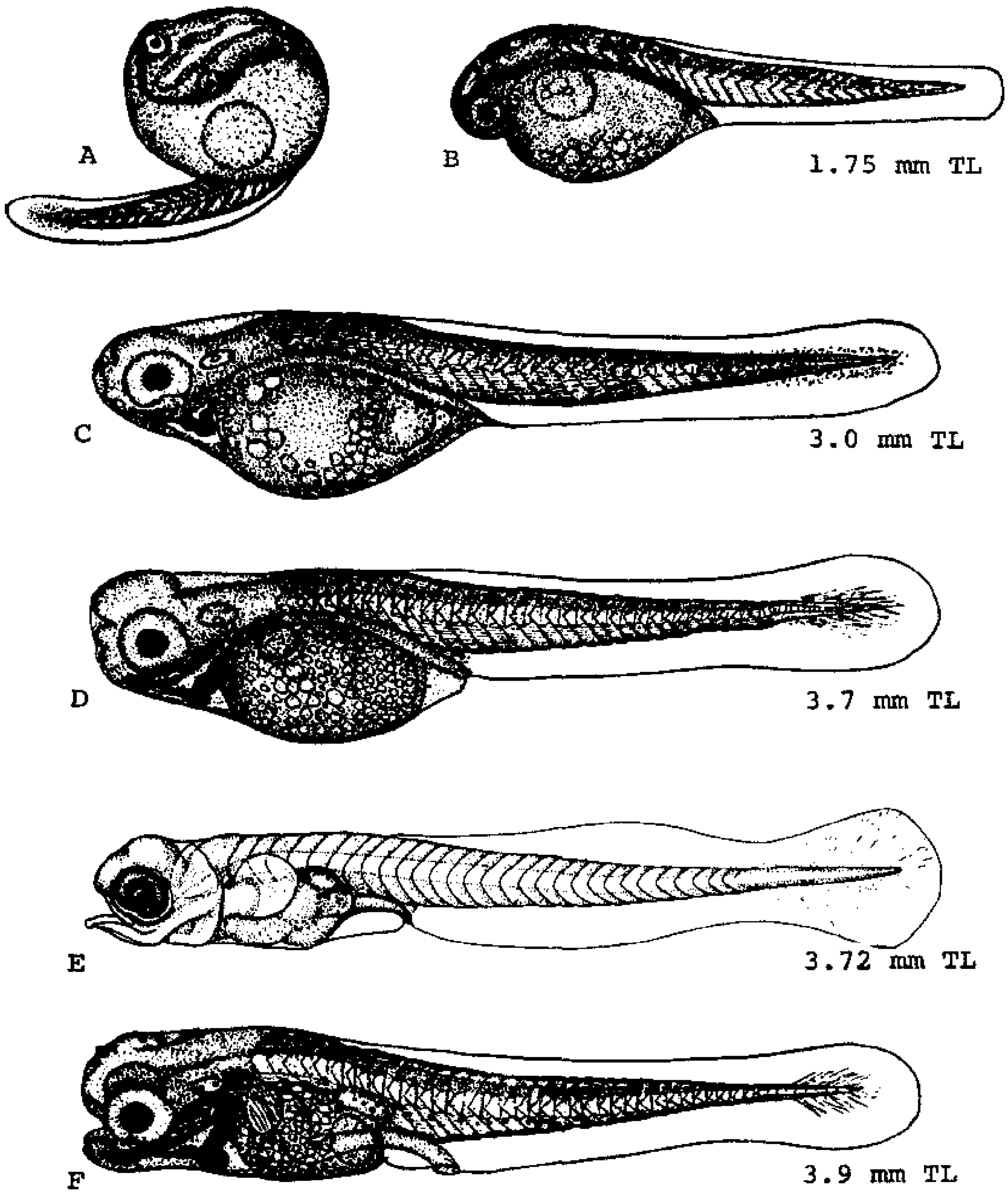

Fig. 165. *Pomoxis annularis*, White crappie. A. Yolk-sac larva, just hatched, size unknown. B. Yolk-sac larva, 7 hours after hatching, 1.75 mm TL. C. Yolk-sac larva, 3.0 mm TL. D. Yolk-sac larva, 3.7 mm TL. E. Yolk-sac larva, 3.72 mm TL. F. Yolk-sac larva, 3.9 mm TL. A-D, F. Specimens from Ohio. E. Origin of specimen unknown. (*A-D, F, Morgan, G. D., 1954: figs. 3, 4. A-C, E, Anjard, C. A., 1974: 193.*)

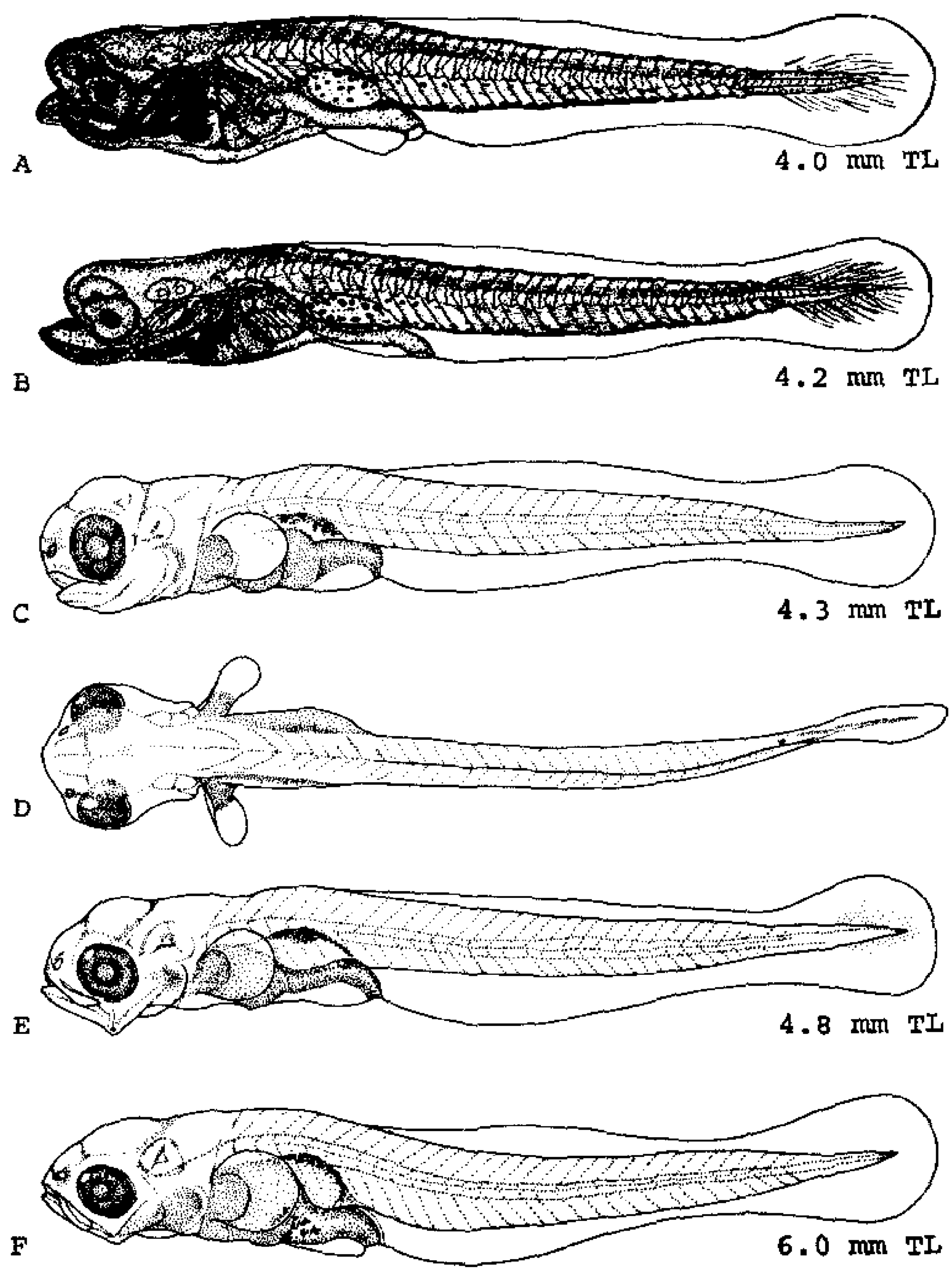

Fig. 168. *Pomoxis annularis,* White crappie. A. Larva, 4.0 mm TL. B. Larva, 4.2 mm TL. C. Larva, 4.3 mm TL. D. Dorsal view of C. E. Larva, 4.8 mm TL. F. Larva, 6.0 mm TL. A, B. Specimens from Ohio. C-F. Specimens from Oklahoma. (*A, B, Morgan, G. D., 1954: fig. 4, D-E. C-F, Taber, C. A., 1969: fig. 16, A, A-C, Elizabeth Ray Peters, delineator.*)

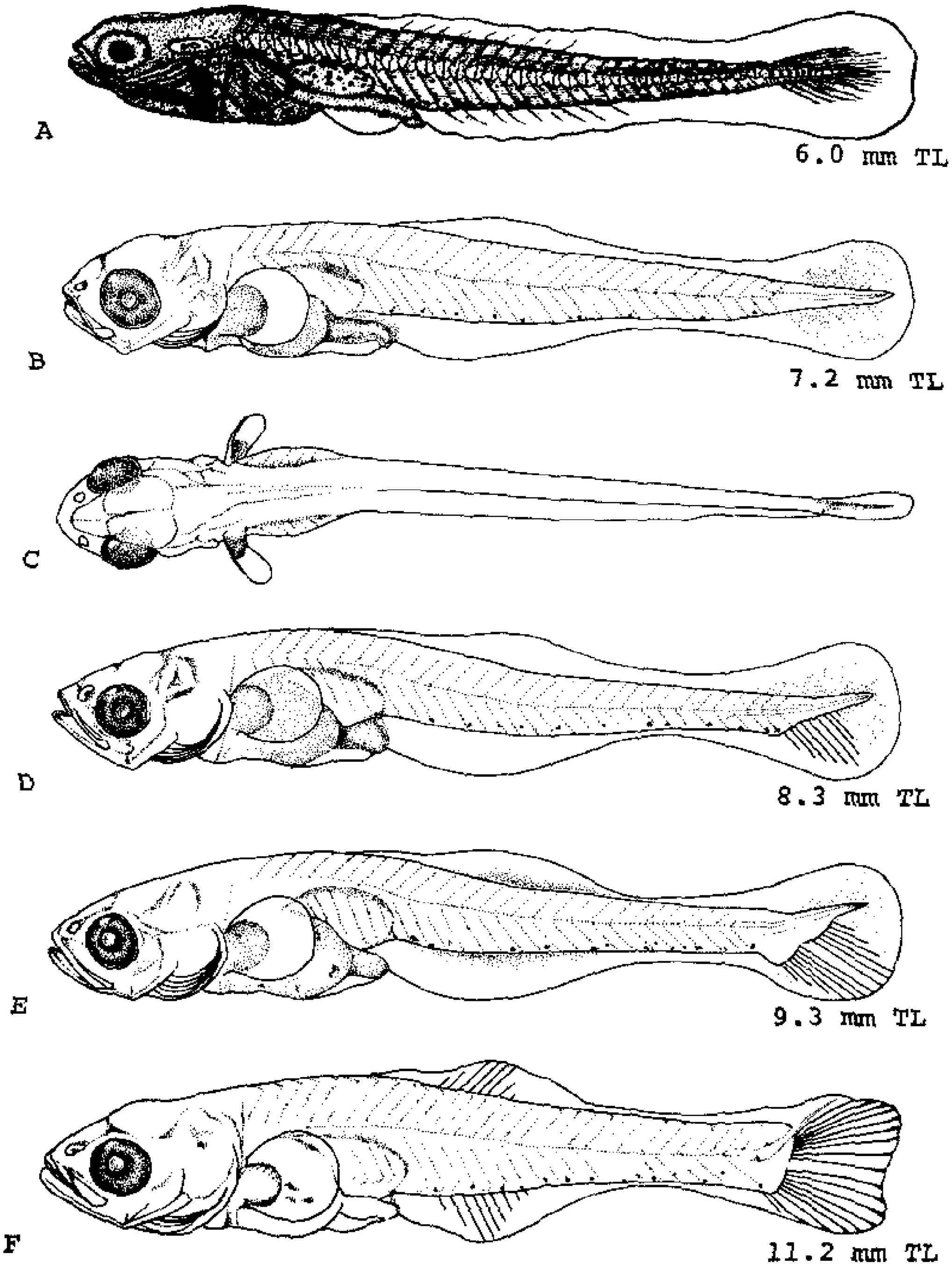

Fig. 167. *Pomoxis annularis*, White crappie. A. Larva, 6.0 mm TL. B. Larva, 7.2 mm TL. C. Dorsal view of B. D. Larva, 8.3 mm TL. E. Larva, 9.3 mm TL. F. Larva, 11.2 mm TL. A. Specimen from Ohio. B-F. Specimens from Oklahoma. (*A, Morgan, G. D., 1954: fig. 4F. B-F, Taber, C. A., 1969: fig. 16, D, D_1-G, Elizabeth Ray Peters, delineator.*)

mented above, otherwise clear; at 7.2 mm a ventral row of widely spaced chromatophores (approximately one *every other myomere) between anus and tail; at 11.2 mm* number and density of ventral pigment spots increased, gas bladder still pigmented above but less densely so than in earlier stages; at 13.5 mm ventral pigment row apparently absent, a few melanophores developed over brain; throughout stage, eye pigmented, no pigment row beneath notochord.[1]

JUVENILES

Minimum size described, 25.5 mm.

At 25.5 mm body depth conspicuously less than in adult, ca. 4.5 times in TL.[1] Scales first evident at 16–19 mm *with scale pockets first evident on lateral line and formed* progressively anteriorly and ventrally to lateral line; scales first imbricated at 22–24 mm; smallest fish with fully formed scales, 27 mm.[5]

Pigmentation: At 25.5 mm TL pigment over head, snout, and lower jaw; a row of spots along ventral ridge of body from midpoint of anal fin to tail; a few chromatophores below dorsal fin, and scattered chromatophores on caudal peduncle; pigment also on membrane of caudal fin and outer half of dorsal.[1] At 52 mm a series of thin vertical bands on body and several broad bands on caudal pe-

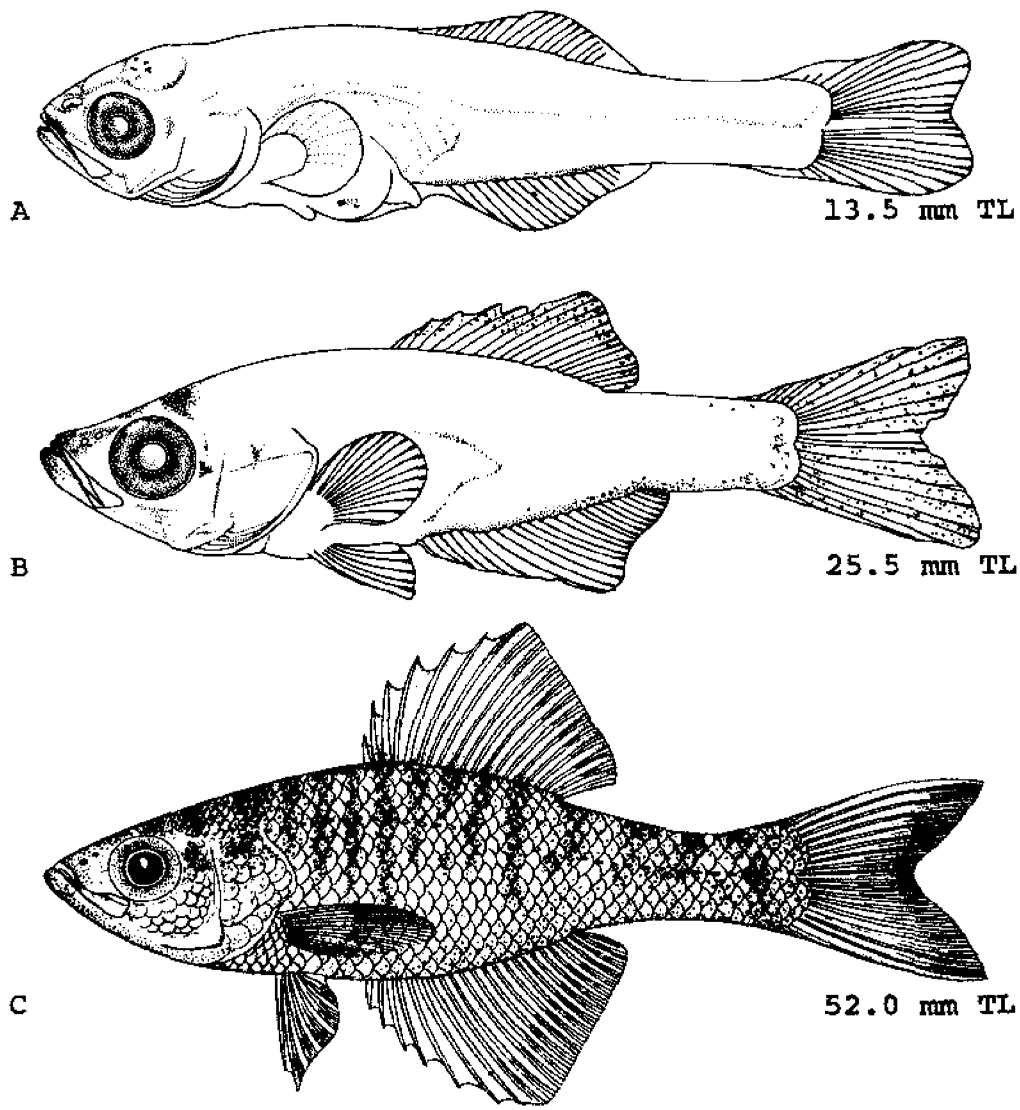

Fig. 168. *Pomoxis annularis*, White crappie. A. Larva, 13.5 mm TL. B. Juvenile, 25.5 mm TL. C. Juvenile, 52.0 mm TL. A, B. Specimens from Oklahoma. C. Specimen from Delaware. *(A, B, Taber, C. A., 1969: fig. 16, H-I, Elizabeth Ray Peters, delineator. C, Fowler, H. W., 1945: 235.)*

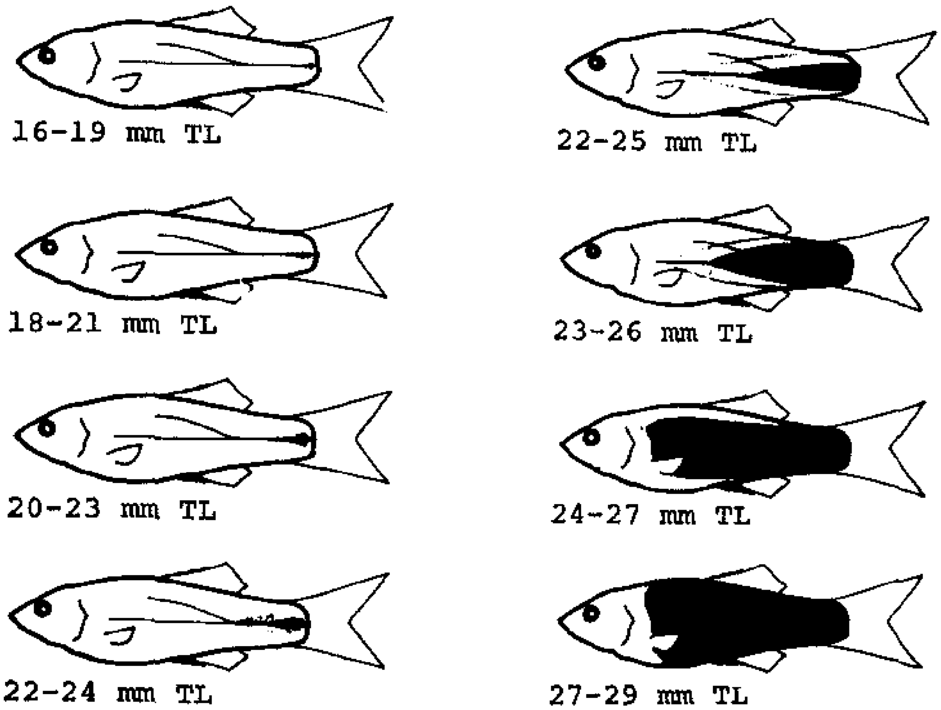

Fig. 169. *Pomoxis annularis,* White crappie. Scale development through a size range of 16–29 mm (*Siefert, R. E., 1965: fig. 1.*)

duncle; small punctations on lower sides of body, abdomen, and caudal peduncle.[28] "Smallest young" described as sometimes faintly spotted, and "small young" as having dorsal, anal, and caudal fins plain or inconspicuously marked.[6] "Young" with "much less black pigment" than adults.[2]

AGE AND SIZE AT MATURITY

Usually mature by 2nd or 3rd year,[2] although some specimens of both sexes are apparently mature at 1 year.[24] Minimum length at maturity 142 mm in an apparently normal population;[29] 109 mm in a stunted population.[6]

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Pomoxis nigromaculatus (Lesueur), Black crappie

ADULTS

D. VI to X,[49] 14–16; [37] A. VI to VIII,[20] 16 [12]–19; P. 13–15; V. I, 5; scales in lateral line 36 [50]–46, above lateral line 7–8, below lateral line 14–16,[20] on cheek 6; [12] gill rakers on lower branch 22–23, on upper branch 5–6; [50] precaudal vertebrae 15; caudal vertebrae 18 [21]–19; [21] total vertebrae 31–33; pyloric caeca 8.[50]

Proportions as percent TL: Greatest depth 29.7–33.3, head 26.6–28.3.[50] Depth typically 2.4 times or less in SL.[22] Eye 25.0–31.6 percent HL.[50] Dorsal base equal to or greater than distance from dorsal origin to posterior orbital rim.[18]

Body elongate [17] (although less so than in white crappie [50]), strongly compressed; [17] mouth oblique; [22] maxillary to posterior edge of pupil; fine teeth on both jaws and palatines; [50] lateral line complete.[17]

Pigmentation: Dorsum golden, olive,[3] or metallic green [50] with overcast of bluish or silvery; [3] sides lighter,[50] grayish to delicate olive green [17] or silvery,[3,19] iridescent throughout, and with mosaic of dark green, blackish,[12] or blue blotches; [3] venter silvery white,[12] milk white,[3] or yellowish; [12] eye variously described as blood red anteriorly and posteriorly, blue-green above [17] or with bright blue pupil and iris of brown, lavender or purplish and with a narrow inner ring of gold; [12,49] dorsal, anal, and caudal heavily reticulated with black, the reticulations with pale green spots in their centers; pectorals dusky and transparent; pelvics opaque and with some black.[3,50]

Maximum length: 486 mm.[50]

DISTRIBUTION AND ECOLOGY

Range: Southern Canada from Manitoba and Lake of the Woods to upper St. Lawrence River, Quebec; south through the Great Lakes region to Mississippi drainage.[18,19,21] In the Mississippi drainage from North Dakota and Montana [50] to western New York and Pennsylvania and south to Texas. Eastward along the Gulf coast to Florida, and northward along the Atlantic coastal plain to North Carolina [18,19,21] or Virginia.[50] Introduced further north on the Atlantic coastal plain, and on the Pacific coast in northwestern United States and British Columbia.[18,19,21] Also introduced in France [49] and Germany.[51]

Area distribution: Introduced in New Jersey,[46] and in tributaries of Chesapeake Bay in Maryland and Virginia.[2]

Habitat and movements: Adults—typically in quiet, clear water among dense aquatic vegetation [5,20,23] (although also recorded from areas with essentially no vegetation [38]) in streams,[5,21] creeks (including tidal-fresh creeks),[25] oxbows,[4] lakes, ponds,[5] impoundments,[3,21] spill pools,[25] lagoons and bayous [29,40] over bottoms of sand, gravel, rubble, silt, clay, mud, muck, or boulders.[3,5,25,38] Sometimes swim in small schools.[47] Recorded temperature range, 4.0–32.5 C. Maximum recorded salinity, 4.9 ppt (but also recorded from water which varied from 3.8–14.9 ppt).[25] Maximum reported depth, 25 m.[14] In fall after temperature falls to ca. 10 C move to deeper water.[5]

Larvae—as yolk-sac larvae in nest guarded by male,[50] as larvae in shallow water along shore; [36,43] also, when somewhat older, in deeper offshore waters. Temperature range, in limnetic waters, 17–20 C.[42]

Migrate from nest area to shallow inshore waters soon after hatching; [43] in May and early June move to limnetic region of lakes.[42]

Juveniles—inshore in weeds and aquatc vegetation, also in lower courses of creeks [9] and at mouths of small streams,[47] and sometimes in limnetic zone of lakes.[52] Recorded from water having surface salinity of 0.2 and bottom salinity of 12.7 ppt.[24]

May move from littoral to limnetic zone of lakes; [52] also from aquatic vegetation along lake shores to mouths of streams in winter when the lakes freeze.[47]

SPAWNING

Location: Over bottoms of gravel, sand,[5,35] clay,[6,27,47] or mud [50] under [5,31] or adjacent to vegetation,[47,48] on clear patches of sand on underwater ridges,[5] along clay banks,[6,27] beneath undercut clay banks,[32,34] and under sod ledges.[15]

Depth: 25 cm [5] to 3 m or more.[15]

Nest: Somewhat circular, 20 [5,48] to 38 cm in diameter,[50] and with bottom composed of coarse and fine sand and, sometimes, shells; [5] adjacent nests usually separated by 1.5 [50] to 2.4 m.[5]

Season: February (based on ripe fish) [8] to August.[5] In Florida approach ripeness in November, ripe or near ripe in February; [8] in Texas early March [13] to early May; [7] in South Carolina early April; [11] in North Carolina March; [26] in Maryland gravid females in May; [28] in Delaware ripe adults late April; [25] in New York May and June; [5] in Ohio late March to early June; [30] in Illinois late April (based on ripe adults of both sexes) to early May; [6,31,39] in Wisconsin May to August; [5,47] in Indiana mid-June into July; [6,48] in Minnesota May to July; [32,33] in South Dakota May.[6]

Temperature: Reproductive activity (including nest

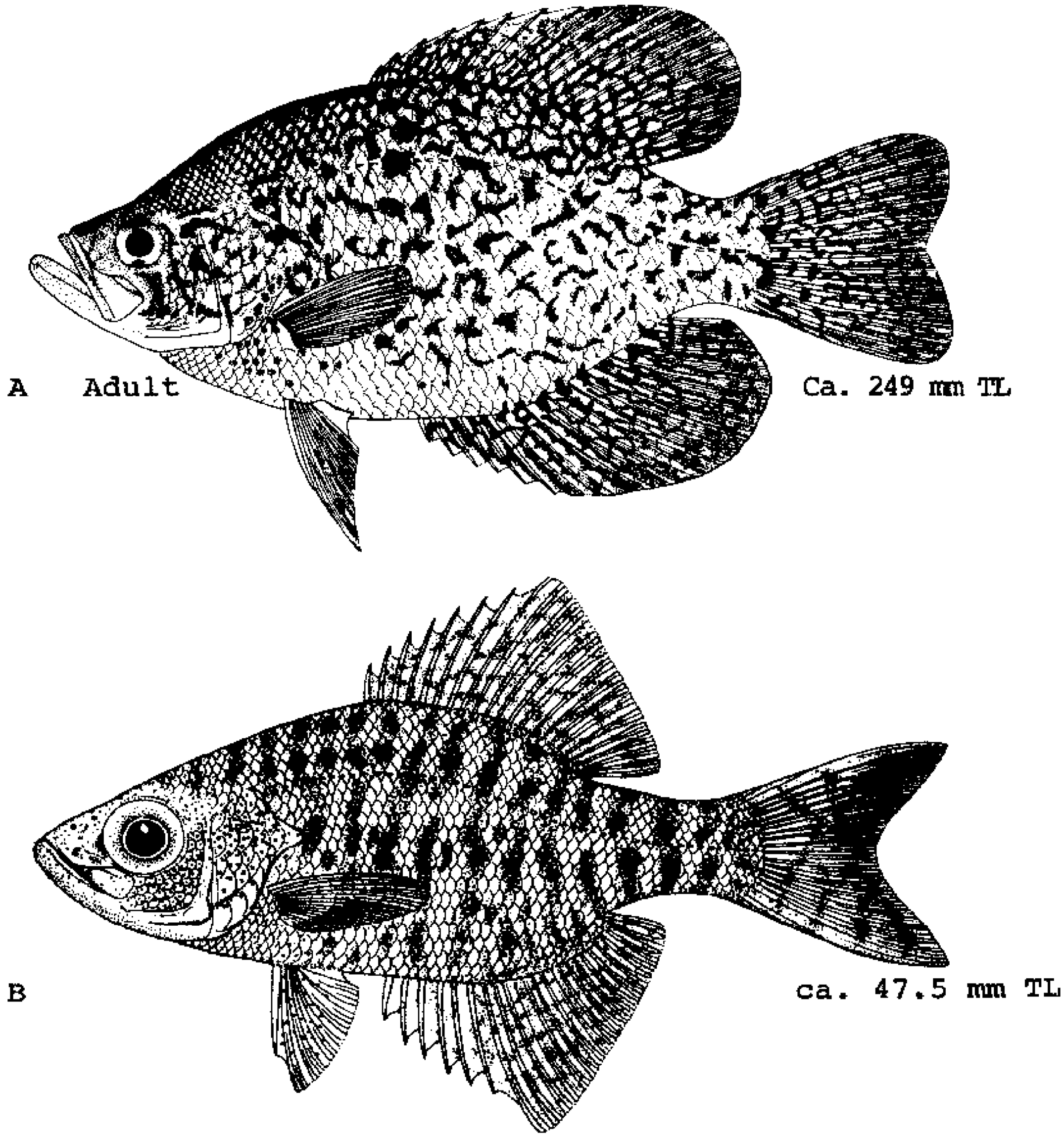


Fig. 170. *Pomoxis nigromaculatus,* Black crappie. A. Adult, ca. 249 mm TL. B. Juvenile, ca. 47.5 mm TL. (*A, Trautman, M. B., 1957: fig. 127. B, Fowler, H. W., 1945: 235.*)

building) recorded at 16–21 C, but with spawning apparently beginning at 19–20 C.[5,6,27,44,47] Records of spawning at minimum of 4.4 C[10] and maximum of 28 C[43] are questioned, JDH.

Fecundity: Variously reported: 26,700–65,520, average 37,796;[50] in a 230 g specimen 98,000;[54] maximum 158,000.[53] Cooper has pointed out that development of ova from oogonia is a continuous process which shows no distinct demarcation of developmental stages.[39]

EGGS

Location: Attached to aquatic plants such as water parsnip, sometimes 5–10 cm above bottom of nest; also to fine roots in bottom of nest.[5,23,31]

Fertilized eggs: Average diameter 0.93 mm±0.082 mm;[45] whitish, adhesive;[50] and presumably with a single oil globule (JDH).

EGG DEVELOPMENT

Incubation period 3–5 days.[50]

YOLK-SAC LARVAE

Hatching length 2.32 mm [44] to, presumably, over 3.0 mm.[37] Yolk gone at "less than 5.0 mm," [44] but oil globule retained to 8.0 mm.[52] Myomere counts variously stated: At 3.5–5.0 mm, mean total myomeres 29.7–31.1, mode 29–31; mean preanal myomeres 10.3–10.7, mode 10–11; mean postanal myomeres 19.5–20.5, mode 19–21.[44] At sizes up to 8.0 mm total myomeres 31–34, mean 32; preanal myomeres 9–10, mode 10; postanal myomeres 21–24, mode 23.[52]

Usually a single oil globule anterior to gas bladder and on right side of future stomach. Rarely several oil globules. Origin of dorsal finfold just above anus or slightly anterior to this point; by 8.0 mm finfold with broad dorsal and ventral depressions in area of future caudal peduncle. Pectoral fins evident at 8.0 mm or less, but without rays.[52]

Pigmentation: Transparent.[5,31] Pigment first evident over gas bladder, along mid-ventral line, sides of head, and anterior part of stomach. Somewhat later, but at lengths of less than 8.0 mm, a prominent subsurface melanophore (characteristic of the species) between dorsal myomere bundles just posterior to head. Also in specimens approaching 8.0 mm chromatophores on both sides of myomeres below horizontal myoseptum, and, in some specimens, a recognizable ventrolateral pigment line.[52]

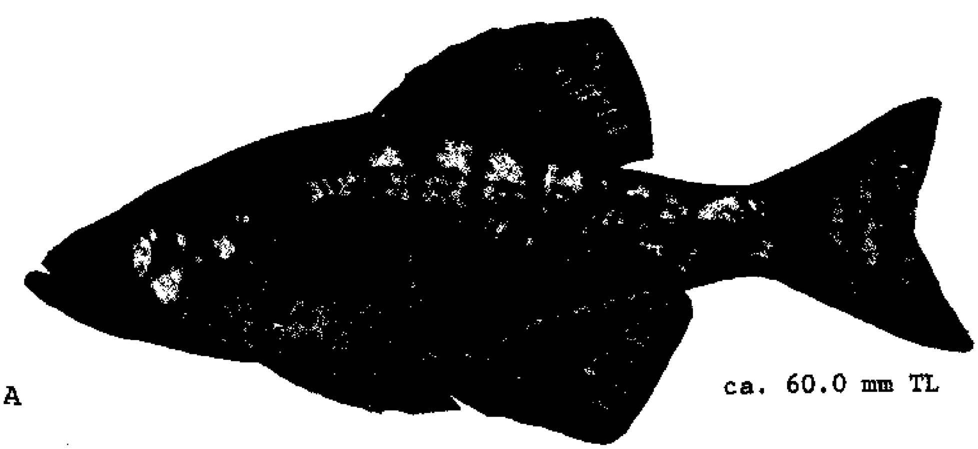
LARVAE

Size range described, 8.0 mm [52]–16.5 mm.

Myomeres variously described: At 5.0–16.5 mm (thus including some yolk-sac larvae), means of total myomeres 31.0–32.3, modes 31–32, becoming stable at 32 at 6.0–6.5 mm; means of preanal myomeres 10.2–14.2, modes 10–14 (mostly 14); means of postanal myomeres 17.8–20.9, modes 18–21.[44] In another study, at sizes approaching 11.0 mm, total myomeres 31–34, mean 32, at sizes approaching 17.0 mm 30–31, mean 30; preanal myomeres, at sizes approaching 11.0 mm, 11–12, mode 12, at sizes approaching 14.0 mm, 12–13, mode 13, at sizes approaching 17 mm, 13–14, mode 14; postanal myomeres, at sizes approaching 11.0 mm, 19–22, mode 20, at sizes approaching 14.0 mm, 18–19, mode 19; at sizes approaching 17.0 mm, 16–17.[52]

Finfold opaque in region of future caudal, dorsal, and anal fins at sizes of 8.0 mm or slightly larger; at ca. 11.0 mm finfold no longer continuous between dorsal and caudal and caudal and anal; a remnant of preanal finfold at 17.0 mm.[52] Incipient rays in soft dorsal and anal at 9.50–9.99 mm, in caudal at 8.50–8.99 mm,[44] and in pectorals at ca. 14.0 mm.[52] Dorsal and anal spines evident at 11.50–11.99 mm.[44] Pelvic buds first evident at 11.0 mm, first pelvic rays at 14.0 mm. Urostyle flexed at 8.0 mm.[52]

Pigmentation: At 8.0–11.0 mm a few chromatophores in future caudal fin, ventrolateral pigment line well-developed. At 11.0–14.0 mm a double ventral pigment line along anal base; scattered melanophores from anal base to caudal base; a lateral pigment line usually evident; ventrolateral pigment line less conspicuous than in previous stage, sometimes absent; usually no pigment behind head or above horizontal myoseptum; melanophores developed on top and sides of head, upper and lower jaws, and on sides of stomach. At 14.0–17.0 mm a double pigment line along dorsal base, a few scattered melanophores posterior to dorsal fin, and, in some specimens, pigment in dorsal and anal fins.[52]



A

ca. 60.0 mm TL

Fig. 171. *Pomoxis nigromaculatus*, Black crappie. A. Juvenile, "somewhat reduced"; illustration as originally published, measured ca. 60.0 mm TL. (*A, Sterba, G., 1967: fig. 796.*)

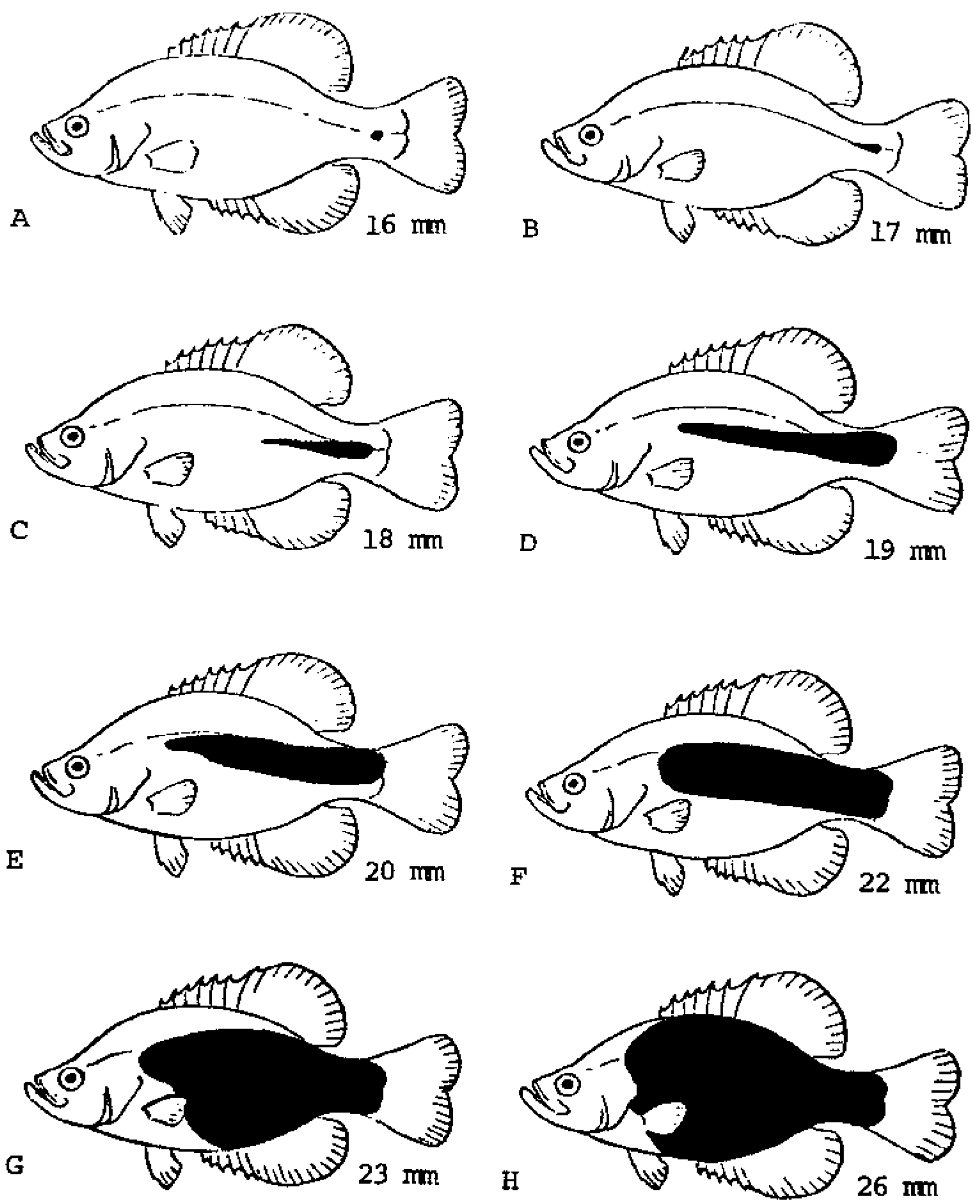


Fig. 172. *Pomoxis nigromaculatus,* Black crappie. A-H. Development of scales through a size range of 16 to 26 mm. (*A-H, Ward, H. C., and E. M. Leonard, 1952: fig. 2.*)

JUVENILES

Scales first evident at minimum length of ca. 16.0 mm, but mean lengths at scales appearance 17.7 mm; scale formation "well advanced" at ca. 20.0 mm.[34]

Pigmentation: "Young" of unspecified size without dark pigment and well defined pattern.[50] In a specimen ca. 47.5 mm long lateral pigment arranged in indefinite vertical bands.[30]

AGE AND SIZE AT MATURITY

Generally mature in 2nd to 4th year,[41,50] but also reported at 1 year;[1] minimum length at maturity, males ca. 150 mm.[5,6,31]

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Etheostoma fusiforme
Etheostoma olmstedi
Etheostoma sellare
Etheostoma serriferum
Etheostoma vitreum
Perca flavescens
Percina caprodes
Percina notogramma
Percina peltata
Stizostedion vitreum

perches
Percidae

FAMILY PERCIDAE

The perches are restricted to the northern hemisphere, occurring from Spain through central Europe to Siberia in Eurasia and from northern Mexico to northern Canada in North America. Early taxonomists either recognized two subfamilies, the Percinae and the Etheostomatinae, or placed the perches (*Perca*, etc.); the walleye, sauger, and pikeperches; and the darters in three distinct subfamilies. Collette (1963b) and Collette and Bănărescu (1977) recognized two subfamilies: Percinae and Luciopercinae. In the Percinae, which includes the perches (*Perca*, *Gymnocephalus*, and *Percarina*) and the North American darters (*Etheostoma*, *Percina*, *Ammocrypta*), the anteriormost interhaemal bone is greatly enlarged, the anal spines are usually well-developed, and the lateral line does not usually extend onto the tail. In the Luciopercinae (*Zingel*, *Stizostedion*) the anteriormost interhaemal bone is no longer than the posterior ones, the anal spines are weak, and the lateral line always extends onto the tail.

In the perches the body is usually elongate, terete, and somewhat compressed. Teeth are present on the jaws, vomer, and palatines; the teeth are usually villiform, but canines are present in some species; the lower pharyngeals are equipped with strong teeth. The preopercle usually ends in a single, flat spine; the two dorsal fins are usually separated, sometimes narrowly joined; the pelvic fins are thoracic; and there are 32–50 vertebrae.

The percids are essentially freshwater fishes, and only rarely enter brackish water. They occur in streams, rivers, and lakes from the warm temperate latitudes of northern Mexico to cold subarctic regions.

Both *Stizostedion vitreum* and *Perca flavescens* make extensive upstream or inshore spawning runs in early spring, with the males arriving on the spawning grounds before the females. The eggs of *Stizostedion* are broadcast at random, while those of *Perca flavescens* are encased in large gelatinous ribbons which may be up to 2.4 meters long. Guardianship of the eggs does not occur in these species.

In the darters, spawning generally occurs on or near stream riffles in moderate to swift current, with only a few species spawning in lakes or in still pools in streams. The eggs may be buried in sand and gravel; placed in organic debris, algae, moss, or rock crevices; or deposited on the undersides of rocks or logs. Courtship and spawning behavior follow species-specific patterns. Males of most species are moderately to strongly territorial (guarding the eggs after deposition); and striking sexual dimorphism, especially in regard to color and fin size, is a common characteristic of the group. Winn (1958a, b) regarded those darters with the most specialized and narrowly adaptive patterns of behavior to be the most recently evolved.

Eggs of the regional percids vary from 1.3 to 2.8 mm in diameter, and are characterized by the presence of a single large oil globule. While most of them are demersal and frequently attached to the substrate, those of *Stizostedion vitreum* may be either demersal or semi-buoyant. In the highly specialized eggs of *Perca flavescens* the chorion is remarkably thickened.

Yolk-sac larvae of percid fishes have well-developed pectoral buds. The yolk sac is large and oval, the oil globule is in the extreme anterior end of the yolk mass, and the anus usually is in advance of the midpoint of the body. Among the regional species hatching length varies from 4.5 to 8.7 mm.

Etheostoma fusiforme (Girard), Swamp darter

ADULTS

D. VII [8] to XIII, 8–13; A. II, 5–10; P. 12–15; [1] transverse scale rows, 41–61; [8] scales in lateral line 40–63 (in Chesapeake Bay area 46–58); pored lateral line scales 1–37 (in Chesapeake Bay area 10–24); [1] scales above lateral line 2 [8]–5,[1] below 6 [6]–12; interorbital scales 0–12 in subspecies *fusiforme*, 1–37 in *barratti;* [1] gill rakers 1+7; [19] preoperculomandibular pores, usually 9; [1] vertebrae 37–40.[2]

Proportions as percent SL: Greatest depth 15–21; length of caudal peduncle 23–30; HL 21–31; distance snout to dorsal fin origin 30–41; highest dorsal spine 8–14; distance snout to anal fin origin 58–66.[20]

Body elongate, moderately compressed; [8] muzzle rather sharp; mouth subterminal, lower jaw included; preopercle with vertical limb moderately serrate, 4–37 serrations on both vertical limbs; [6] maxillary to anterior edge of pupil; [19] interorbital pores absent. Breast [1] and nape scaled. Lateral line incomplete, strongly elevated anteriorly,[6] occasionally lacking.[8] Breeding tubercles developed on spines and distal portions of soft anal and pelvic rays in breeding males.[20]

Pigmentation: Color extremely variable, changing with color of water.[1] Brownish above,[14] with 7 [8] to 12 dorsal saddles (although these sometimes obscure or absent) alternating with lateral blotches; sides with 6–13 dark brown or black blotches below lateral line, these sometimes tending to fuse into dark lateral band; [1] lateral blotches obscure in large adults; [6] a vertical dark bar behind pectoral fin base; breast and belly immaculate or with scattered melanophores.[1,8] Cheeks and mandible with small dark blotches or round spots; [6] 4 orbital bars, the suborbital most prominent. Melanophores on posterior edge of first dorsal fin and membrane of second dorsal fin; [1] caudal [6] and pectoral fins barred; pelvic fins with scattered melanophores.[1]

Breeding males dark throughout; [1] breast and throat sprinkled with large melanophores (larger than those on belly); a blackish crescent beneath almost every other scale except on lower sides and belly; anal and pelvic fins heavily speckled; [20] dorsal melanophores coalesced into solid black band.[1]

Color in life dark brown with dark green between dark spots on body, sides with flush of greenish yellow to orange-yellow; a brilliant, iridescent, greenish spot in front of pectoral fin base; lower parts pearly; [20] bronzed green metallic reflections on opercle and preopercle; iris brown, pale silvery or whitish below; [19] caudal, dorsal, and anal fins alternately barred with dark red and yellow; dorsal sometimes with indistinct blotches of orange.[20]

Maximum length: 52 mm SL.[20]

DISTRIBUTION AND ECOLOGY

Range: Atlantic Coastal Plain from southeastern Maine to Dade County, Florida; [1] recorded throughout most of peninsular Florida (including Lake Okeechobee); [14] from Collier County on the west coast of Florida [1] to Okla-

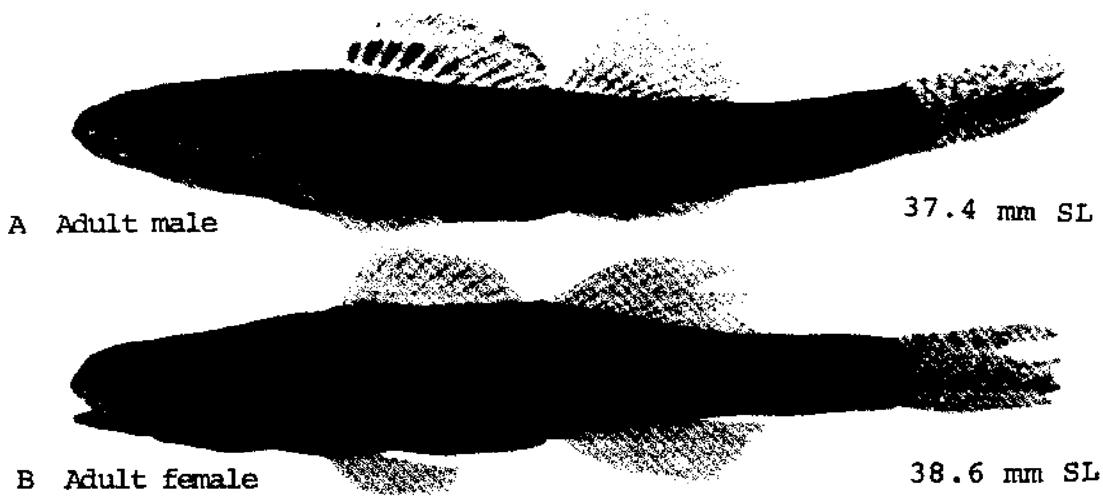

Fig. 173. *Etheostoma fusiforme,* Swamp darter. A. Adult male, 37.4 mm SL. B. Adult female, 38.6 mm SL. (*A, B, Collette, B. B., 1962: figs. 6, 7.*)

homa, and Red River, Texas;[13] also recorded from ponds near Asheville, North Carolina (French Broad River drainage), but population probably introduced.[1]

Area distribution: In Maryland known only in Zekiah Swamp, Charles County, the lower Potomac River, and on the Delmarva Peninsula; recorded from various rivers in Virginia and New Jersey.[1,15]

Habitat and movements: Adults—found in ponds,[5,11,15] mudholes,[1] boggy areas,[18] swamps, sloughs,[1] canals,[4] mill ponds,[1] overflow pools,[20] large lakes[10] (primarily at edges[14]), sluggish lowland streams, backwaters of streams,[7] and on riffles above swamps[20] over bottoms of mud,[1,14] mud and leaf mold, sand, sand and clay, and, rarely, rock and gravel;[8,20] rarely in flowing water;[1] associated (although not always) with vegetation[20] such as cypress roots, *Xyris* beds,[6] water hyacinths,[9] water lilies,[1] sphagnum,[19] filamentous algae,[1] sedges, and flooded turf;[20] shows definite affinity for floating islands;[12,16,17] found in muddy and clear water, but typically in "black water" or "coffee-water" (acid);[7,20] occasionally in especially warm, stagnant water. Depth range 76 mm[1] to 1.8 m;[20] maximum recorded salinity, 1.3 ppt,[3] but also recorded from pond in which salinities as high as 2.0 ppt were recorded;[15] temperature range, 9–32 C;[20] pH range, 3.7[1]–8.1.[15]

Larvae—"postlarvae" in a school (20–30 individuals) at surface in 150 mm to 16 m of water over open sand.[15] During first month (thus probably including some juveniles), swim at surface.[22]

Juveniles—recorded from sluggish, slightly acid streams;[15] specimens 13.3–22.0 mm long (thus possibly including larvae) about 9 m offshore on open sand in water 1.2–1.5 m deep.[1] At age of 2 months "confirmed bottom swimmers."[22]

SPAWNING

Location: Probably at surface; in aquarium observations female lead male up to floating algae.[1]

Season: In Florida ripe adults February and March[21] (although distinctive sexual differences develop in September[20]); in New Jersey courtship began in aquarium soon after capture on March 27, but field population had not completed spawning by May 17; in Long Island, New York, specimens collected April 21 began prespawning behavior almost at once in aquarium;[1] in Massachusetts and Rhode Island probably early May.[20]

Fecundity: Unknown.

EGGS

Attached singly to leaves of *Myriophyllum;* also apparently the undersides of lilies.[1]

EGG DEVELOPMENT

Incubation period: 8–10 days at unspecified temperature.[1]

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Minimum size described, 12 mm (thus possibly including some larvae).

Supratemporal canal developing in some specimens at 12.0–13.9 mm, first evident in others at 18.0–19.9 mm; size when supratemporal canal first complete, 16.0–17.9 mm to 20.0–21.9 mm. Scales first evident on caudal peduncle at base of caudal fin, thereafter extend forward along lateral line and dorsally and ventrally; minimum size at which scales first evident, 12.6 mm; scales "nearly complete" at minimum length of 15.6 mm; smallest specimen with fully developed pored scales 16.5 mm, pored scales complete at about 20 mm.[1]

Pigmentation: In "juveniles" lateral bars and dorsal blotches more distinct; underside of "young" almost without pigment.[6]

AGE AND SIZE AT MATURITY

Minimum length at maturity, females 24.5 mm SL, males 28.1 mm SL.[1]

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Etheostoma olmstedi Storer, Tessellated darter

ADULTS

D. VIII to X,[9] 10–17;[8,10,12] A. I to II,[9] 5–10;[8] P. 9–15; lateral line scales 39–64;[12] scales above lateral line 4[15]–7;[9] below lateral line 6[15]–10;[9] infraorbital canal pores 4–11;[4] preopercular canal pores 7–11;[16] preoperculomandibular canal pores 10–11;[15] vertebrae 37–39.[1]

Proportions as times in SL: Head length 3.85–4.15, depth 5.45–6.10. Proportions as times in TL: SL 1.16–1.24; snout to end of pectoral fin length 2.18–2.35; pectoral fin length 4.20–4.89; head length 4.00–5.22.[6] Eye diameter 3.50–3.75[17] times in HL.

Body elongate, fusiform,[12] scarcely compressed except for caudal peduncle;[17] caudal peduncle noticeably elongate;[25] snout subconical, slightly inclined;[15] mouth ventral or subterminal,[9] slightly oblique;[12] maxillary to or a little beyond anterior margin of eye; opercle ending in strong spine. Lateral line complete.[17] Pectoral and pelvic fins widely pointed;[15] in breeding males vertical fins greatly enlarged.[7]

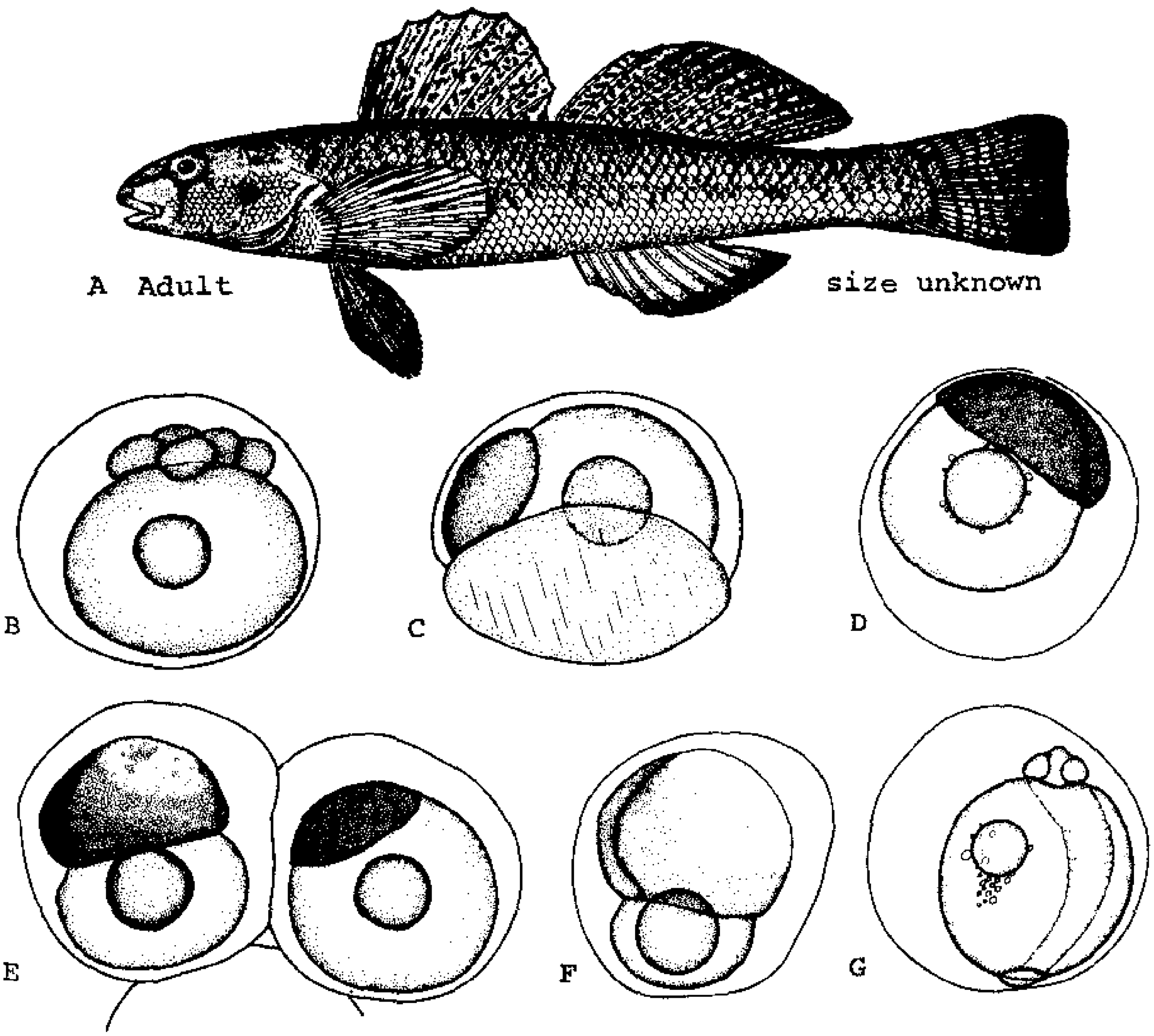

Fig. 174. *Etheostoma olmstedi*, Tessellated darter. A. Adult, size unknown. B. 8-cell stage. C. Late morula, cells extremely small (note well-developed attachment disc). D. Blastoderm over one-third of yolk, anterior end of embryo enlarged. E. Variation in degree of development within a single batch of eggs from late morula to well-developed embryo. F. Blastoderm over three-fourths of yolk (note constriction in yolk). G. 8-cell stage, eyes forming. (*A, Jordan, D. S., 1905: fig. 247. B–G, Original illustrations, Jerry D. Hardy, Jr.*)

Pigmentation: Body olivaceous [9] with 6–8 saddle-like blotches,[17] the first just before first dorsal fin origin.[12] Sides olivaceous,[17] but lighter than dorsum; [9] 9–11 [12] irregular dark markings [17] usually characterized as X's or Y's; dorsolaterally irregular dark brownish spots in uneven rows; ventrolaterally usually immaculate.[12] Venter "pale" [17] or yellowish.[9] Head with a dark brown line from ventral point of orbit to point just posterior to end of maxillary; a less distinct line anterior to orbit and passing anteroventrally beneath anterior nasal opening, then medially, ending at mid-snout; [12,17] iris plumbeous slate color.[25] First dorsal, second dorsal, and anal fins with *alternating sand-colored and darker brown blotches tending* to form concentric bands; anal, caudal, and pelvic fins described as "plain" or "immaculate." [12,17]

Breeding males darkest dorsally, with saddle markings indistinct.[7] Sides dark,[3] olive gray [7] to deep brown; [12] W-marks indistinct or absent; [7] sometimes with about 10 vertical bars; [8] scales along lateral line outlined in brownish black.[12] Head with metallic coloring. Membrane between 1st and 3rd dorsal spines mesially jet black,[7] rest of dorsal fin dusky; anal fin dusky,[3] slate-gray, black,[7] or blackened toward ray tips; [12] caudal fin dusky; pectoral fins clear [3] or with traces of mottling; [7] pelvic fins dusky,[3] slate-gray or black,[7] and with whitened tips.[15]

Maximum length: 88.4 mm.[14]

DISTRIBUTION AND ECOLOGY

Range: Eastern United States from eastern Massachusetts and southern New Hampshire southward to St. Johns River, Florida; restricted to Atlantic and Lake Ontario drainages; south of Susquehanna River known only from *below Fall Line except in Rappahannock, Santee-Cooper,* and Peedee Rivers; [12] reported from Oklawaha River, Florida,[21] but systematic status of this population unclear.[20]

Area distribution: Throughout Chesapeake Bay area in Virginia and Maryland; [5,17,24] Delaware; [26] New Jersey.[25]

Habitat and movements: Adults—a bottom species [18] found in streams,[9,14] creeks,[25] brooks,[18] swamp runs,[24] and, less frequently,[9] ponds and lakes; [14,23] in running water on riffles as well as in quiet water [9] or still shallow pools; [25] in lakes usually over shallow shoal areas; [14] recorded from a variety of bottom types including sand,[19,25] silt,[23] mud,[14] clay, gravel, and stone; [22,23] sometimes associated with aquatic vegetation; [16,19] recorded from both clear [17] and muddy water; [16] sometimes burrows in sand with only eyes protruding.[14] Maximum recorded salinity, 13.0 ppt.[24]

Larvae—no information.

Juveniles—maximum recorded salinity, 0.1–0.5 ppt; maximum recorded temperature 16.5 C.[26]

SPAWNING

Location: In moderate current in water less than 30.5 cm [3] to up to 61.0 cm deep [14] over bottoms of marl, sand, gravel, or stone; [3] usually under rocks [11] or other objects on bottom; [14] males guard eggs [9] and appear, in some cases, to actively dig nest site,[3] as many as 3 or 4 males may hold territories under one rock.[11]

Season: In Maryland, May (or perhaps April) to June (late June in cold water environments); evidence of onset of reproductive period based, in part, on increased mean ovum diameter in April or, perhaps, early March; [21] in aquaria in April and May; [3,13] eggs on June 27 in Oneida Lake, New York.[14]

Time: Observed to occur in aquaria at about 0840–1130.[3]

Temperature: Under aquarium conditions, 18.3 C.[3]

Fecundity: 54–300 in age group I fish; 156–428 in age group II fish; 418–668 in age group III fish.[27]

EGGS

Location: Demersal (JDH); guarded by male; deposited in single layer in mass 2.4–7.6 cm wide on both undersides and uppersides of stones and rocks, and on undersides of logs, boards, debris, freshwater mussel shells, *and miscellaneous objects such as pieces of tin.*[3,13,14,19]

Ovarian eggs: In three principal classes; class I, 1.13–1.60 mm (mean 1.35 mm), class II, 0.2–1.0 mm, class III, 0.05-0.2 mm.[27]

Fertilized eggs: Approximately spherical, diameter ca. 1.5 mm; yolk amber; a single exceptionally dark amber oil globule,[3] and, in some specimens, numerous minute oil globules surrounding major globule (JDH).

EGG DEVELOPMENT

Cleavage stages	at 4- to 16-cell stages blastomeres somewhat irregular, perivitelline space about one-fourth of the egg diameter.
Morula stage	cells relatively small before descent of blastoderm over yolk.
Early embryo stage	blastoderm over one-third of yolk, anterior end of embryo enlarged.
Advancing embryo stage	blastoderm over three-fourths of yolk, yolk noticeably constricted.
Eye embryo stage	eyes forming, unpigmented; lenses not yet evident; about 8 somites.

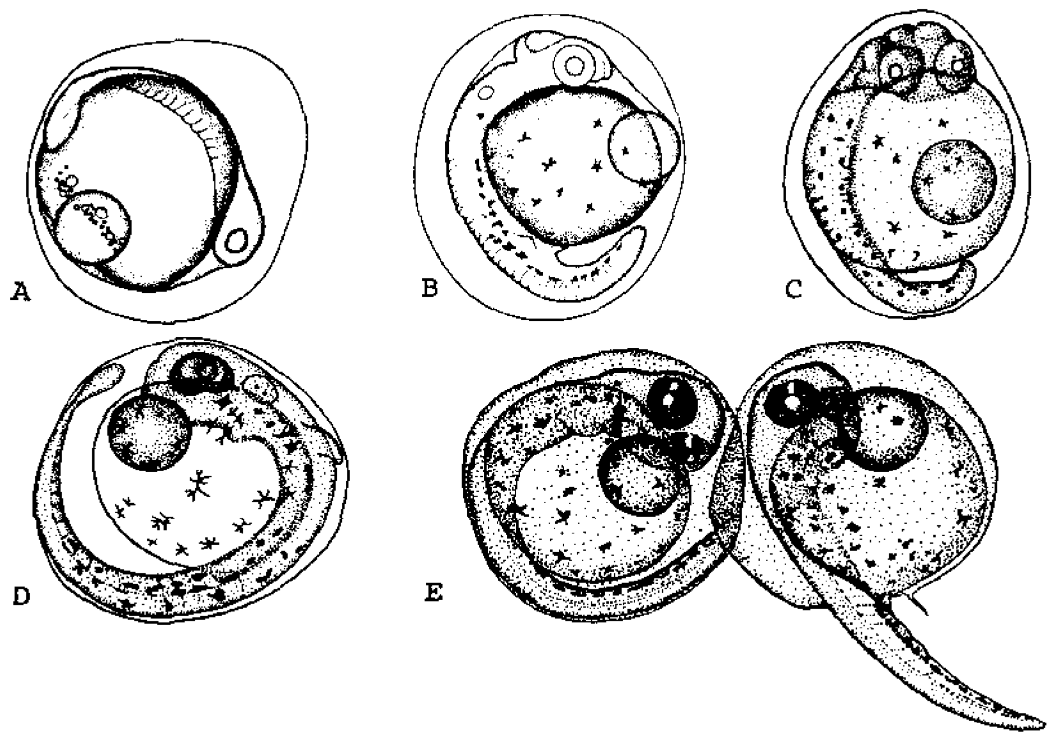

Fig. 175. *Etheostoma olmstedi*, Tessellated darter. A. Ca. 18-somite stage, lenses, otocysts not yet evident. B. 32-somite stage, lenses, otocysts formed, pigment on yolk sac and body. C. Eye pigmentation. D. Otolith formation, pectoral buds evident. E. Prehatching stage. (*A, C, Original illustrations, Jerry D. Hardy, Jr. B, D, E, Original illustrations, Deborah C. Kennedy.*)

Tail-free stage	18+ somites, lenses, otocysts not yet evident.
32-somite stage	lenses, otocysts formed; pigment in double row on posterior part of body and yolk sac.
Eye pigmentation stage	pigment in eye faint, pectoral fins not evident.
Otolith formation stage	tail essentially around yolk, pigment increased, pectoral buds evident.
Prehatching stage	eye darkly pigmented, ventral pigment row heavier than in previous stages (JDH).

Incubation period, unknown, but will develop at 18.3 C.[3]

YOLK-SAC LARVAE

Hatching length, unknown. Size range described, 5.1–5.8 mm.

Yolk sac initially very large, more or less spherical; oil globule in anterior part of yolk sac on level with pectoral fin base. Mouth open at 5.8 mm. Preanal finfold relatively short, narrow; pectoral fins rayless throughout size range described.

Pigmentation: At 5.1 mm TL large stellate chromatophores over yolk sac; chromatophores in conspicuous double row ventrally between anus and tip of tail, and between yolk sac and body. At 5.3 mm yolk-sac pigment concentrated along vitelline vessels. At 5.5 mm faint evidence of pigment on dorsal aspect of head. In a specimen of unknown length, but more advanced than previous stages, conspicuous stellate melanophores on top of head and near posterior end of dorsal ridge (JDH).

LARVAE

No information.

JUVENILES

Minimum size described, ca. 37 mm SL.

Pigmentation: At about 37 mm SL pigment on sides not in definite W's, a row of pigment over gut, weakly developed pigment in 1st and 2nd dorsal and caudal fins,

A

B

C

D

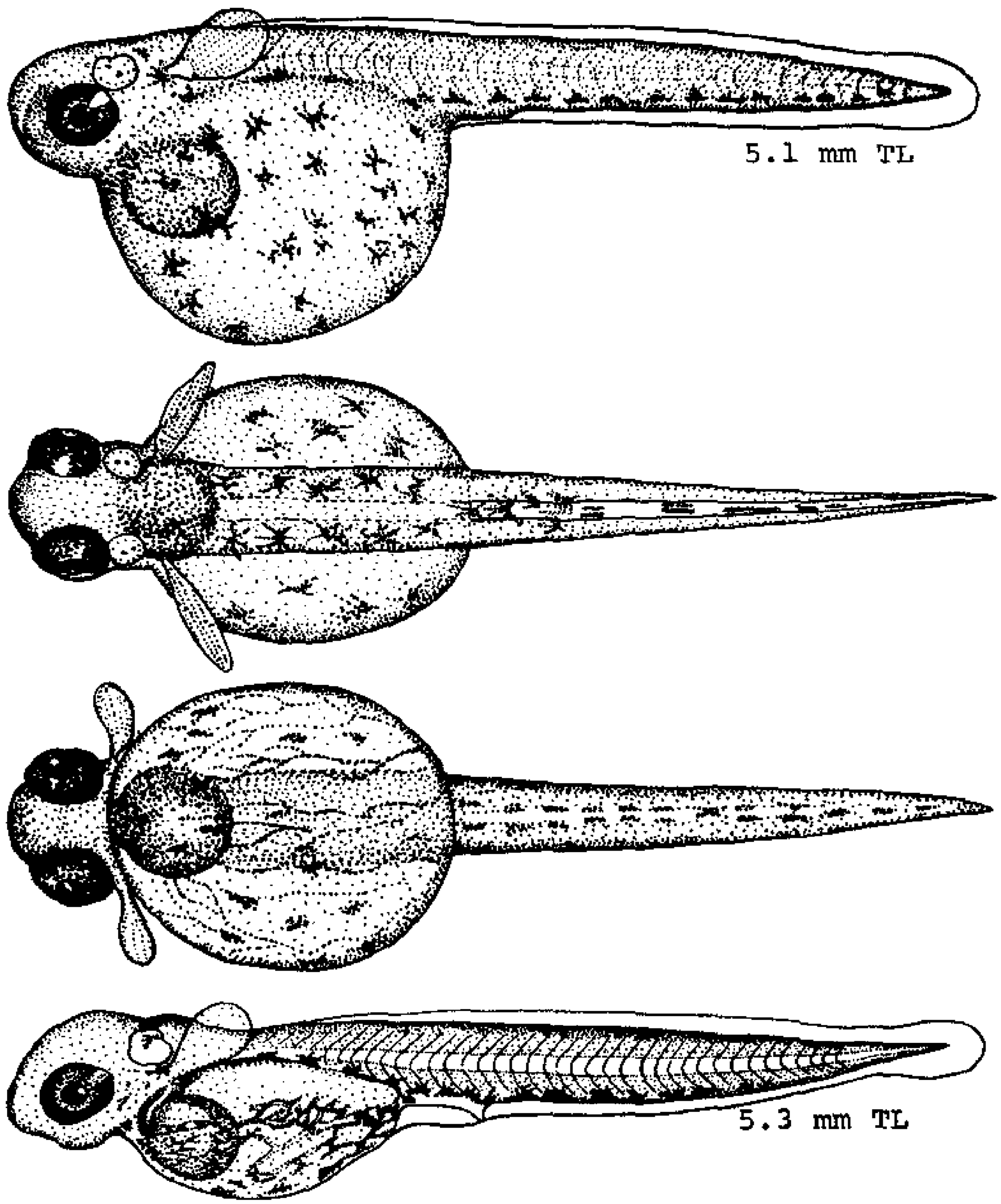

Fig. 176. *Etheostoma olmstedi*, Tessellated darter. A. Yolk-sac larva, 5.1 mm TL. B. Dorsal view of A. C. Ventral view of A. D. Yolk-sac larva, 5.3 mm TL. (*A-D, Original illustrations, Deborah C. Kennedy.*)

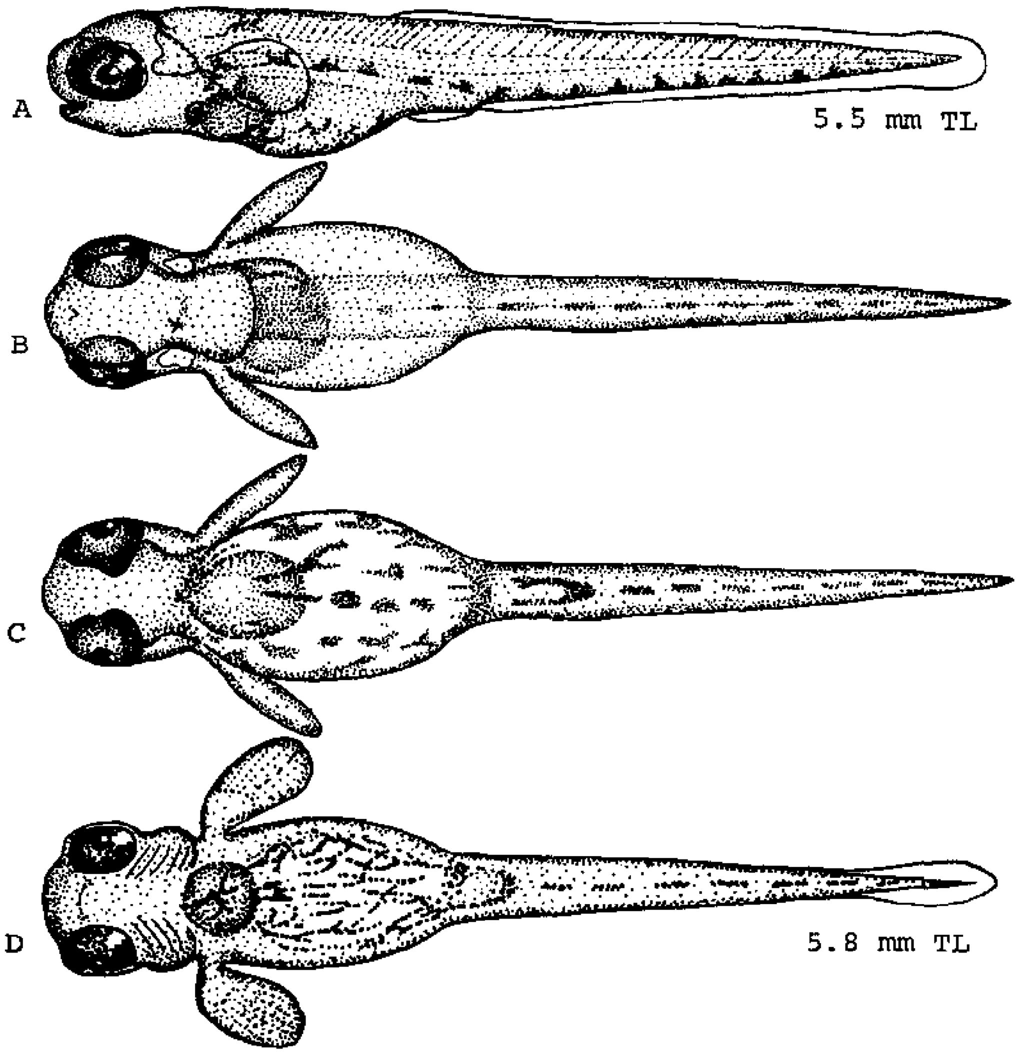

Fig. 177. *Etheostoma olmstedi,* Tessellated darter. A. Yolk-sac larva, 5.5 mm TL. B. Dorsal view of A. C. Ventral view of A. D. Yolk-sac larva, 5.8 mm TL, ventral view, showing increased ventral pigment. (*A-D, Original illustrations, Deborah C. Kennedy.*)

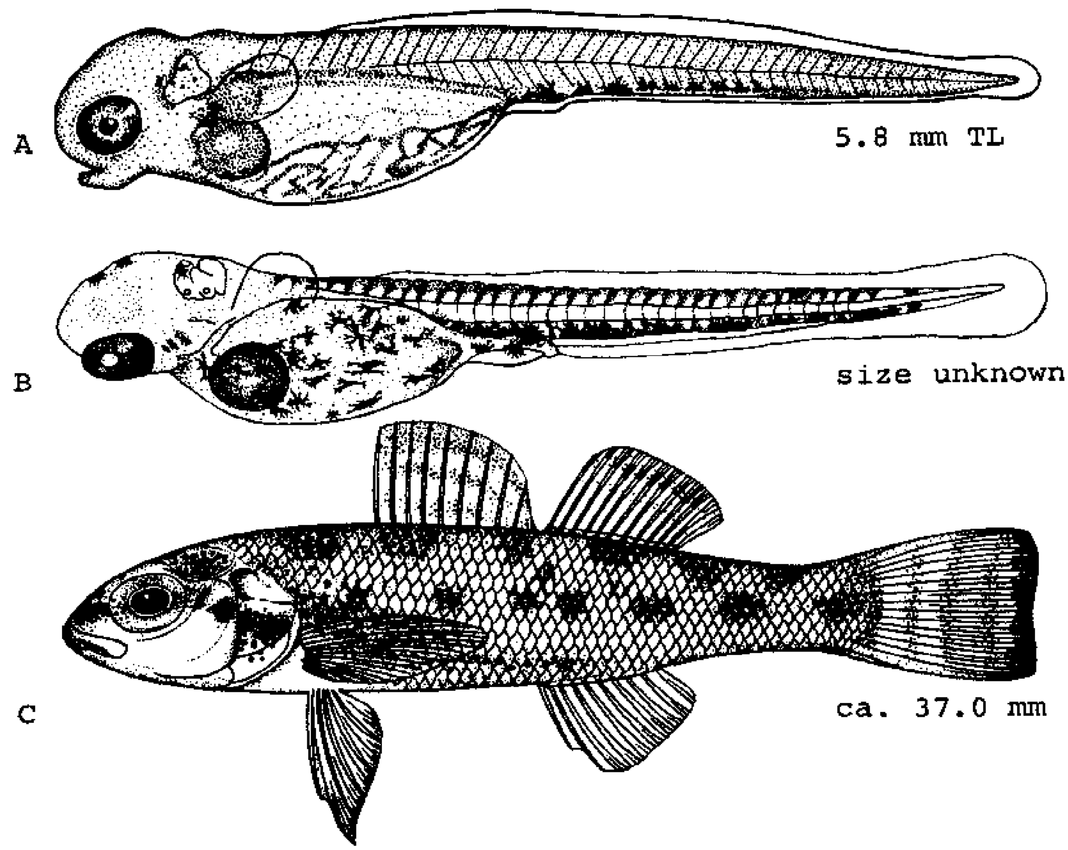

Fig. 178. *Etheostoma olmstedi*, Tessellated darter. A. Yolk-sac larva, 5.8 mm. B. Yolk-sac larva, size unknown, somewhat more advanced than previous stage, pigment developing dorsally. C. Juvenile, ca. 37.0 mm TL. (*A, Original illustration, Deborah C. Kennedy. B, Original illustration, Jerry D. Hardy, Jr. C, Fowler, H. W., 1945: fig. 36.*)

no pigment in pelvic and anal fins.[28] "Young" similar to adult female, but paler and with fewer spots and small specks.[25]

AGE AND SIZE AT MATURITY

Some of each sex when 1 year old, all by 2 years.[2] Both sexes mature at 40 mm.[7,17]

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Etheostoma sellare (Radcliffe and Welsh), Maryland darter

ADULTS

D. VII to XII, 11–13; A. II, 8–10; P. 13–15; lateral line scales 43–53 (average 46.8); diagonal scales 6–9; least caudal peduncle scales 16–19; preoperculomandibular pores 9–10; lateral canal pores 4–5; infraorbital canal pores 8–10; pyloric caeca 2; vertebrae 14–16 (average 14.9)+24–27 (average 25.2).[5]

Proportions as times in head: Eye 3.55–3.67, snout 3.14, maxillary 2.82, interorbital 8.46–8.80, pectoral fin 0.92.[2]

Body slender, fusiform;[2] belly essentially naked; anus surrounded by a blunt, striated lobe.[5] Head broader than deep; gape nearly to anterior margin of pupil;[2] snout moderately produced; premaxillary frenum present; infraorbital and supratemporal canals complete, top of head, nape, breast, and preopercular areas scaleless. Lateral line straight, complete.[5]

Pigmentation: In alcohol (based on type specimens) light smoke-gray, becoming white on ventral surface; back crossed by 4 black saddles with light margins, these broadest dorsally but narrower than the interspaces; first dorsal blotch in front of spinous dorsal and extended downward to pectoral base; the second between base of next to last dorsal spine and origin of 2nd dorsal and extended laterally to below lateral line; the 3rd between 6th and last dorsal ray and downward to within 2 scales of anal base; the 4th in front of caudal base and downward to ventral surface of caudal peduncle. Below lateral line and alternating with black saddles 4 black quadrate blotches, the last on the caudal base. Several scales on each side of base of spinous dorsal between 1st and 2nd dorsal saddle black. Dorsal spines with few dusky or black markings, the soft dorsal crossed by 3 rows of blackish spots; caudal with dusky mottling; anal and ventrals white; pectorals crossed with 5 rows of blackish spots. A black spot behind eye, a black bar in front of eye, a 2nd below eye, and a 3rd from upper margin of pupil on to interorbital area.[2] Also, based on recently preserved specimens, stippled with dark brown spots; background of back and sides brownish; lower sides yellowish; 4 or 5 brown saddles extending below lateral line, the widest saddle between the dorsal fins; usually 3–5 dark brown blotches in spaces between saddles just below lateral line; 2 small yellowish areas near base of caudal fin; a dark prepectoral bar and below this 2 discrete brown blotches; dark brown spots on all fins, those on rays more or less aligned to give appearance of bands.[5]

Color in life: Interspaces between saddles and lateral blotches and light areas of head and nape golden to olivaceous; lower sides and belly usually whitish, but sometimes with golden cast; fin spots creating appearance of alternating brown and yellow bands; a yellow-orange blotch at pelvic base; prepectoral spot golden orange; anterior rim of eye golden, pupil blackish, iris golden.[5]

Maximum length: 70.0 mm SL.[5]

DISTRIBUTION AND ECOLOGY

Range: Swan Creek, Deer Creek, and Gasheys Run, Hartford County, Maryland.[3,4]

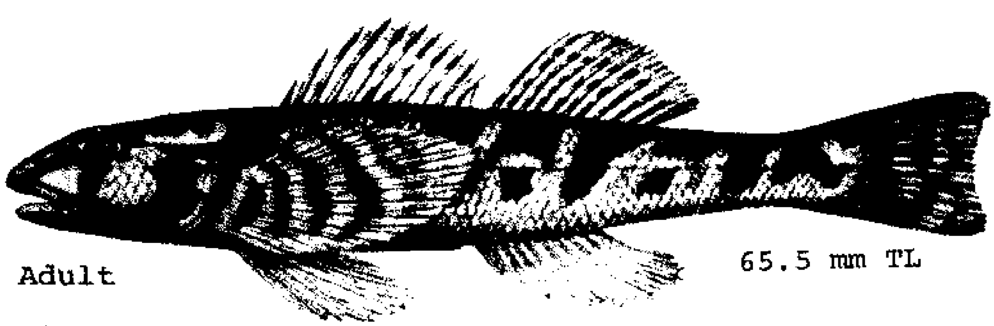
Area distribution: See "Range" above. Species considered rare and endangered throughout its range.[3,4,6]

Habitat and movements: Adults—clear, rapid flowing, gravelly streams.[4] The largest known population is from a riffle area just above tidewater in Deer Creek.[5]

Larvae—no information.

Juveniles—a 21 mm SL specimen in a stream consisting of riffles and pools over bottom of sand and fine gravel.[1]

A Adult



65.5 mm TL

Fig. 179. *Etheostoma sellare,* Maryland darter. A. Adult, 65.5 mm TL, the holotype. (*A, Radcliffe, L., and W. W. Welsh, 1914: pl. 18.*)

Other juveniles from just above and below the riffle on Deer Creek.[5]

SPAWNING

Season: Possibly early in mid-April, adults from May 18 are postspawning; *gonads and urogenital papillae well-developed November 10.*[5]

EGGS

Ovarian eggs: Ovarian eggs observed in November averaged 1.0 mm in diameter.[5]

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Pigmentation: In a juvenile 22 mm SL a series of X's and W's along trunk similar to those in tessellated darter, *Etheostoma olmstedi.*[5]

AGE AND SIZE AT MATURITY

No information.

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Etheostoma serriferum (Hubbs and Cannon), Sawcheek darter

ADULTS

D. IX to XIII, 11–17;[1] A. II,[4] 5–9;[1] scales in lateral series 40[1]–66; pored scales in lateral line 20–45; scales above lateral line 3–5, below 10–15; interorbital scales 6–35;[1] vertebrae 38–40.[2]

Muzzle blunt; mouth terminal, somewhat oblique;[6] preopercle conspicuously serrate;[1] cheeks, opercle, nape, breast, and top of head scaly; lateral line incomplete, elevated.[4]

Pigmentation: A series of 7–9 poorly developed dorsal saddles[1] usually present; sides with a row of large, irregular dark blotches which may be partly confluent or fused to form lateral stripe; first lateral blotch typically distinct and higher than remainder in series; pored portion of lateral line with narrow, often indistinct light line; base of caudal fin with vertical row of 4 dark dots, the median 2 very intense;[6] some individuals with uniformly tan sides and without lateral blotches;[1] 4 orbital bars present; lower jaw and throat light. In breeding males lower sides with numerous evenly spaced melanophores;[6] basal portion of first dorsal fin almost solid black;[1] second dorsal fin sprinkled as well as barred;[6] anal, pelvic fins, belly, and breast uniformly covered with small melanophores.[1]

Maximum length: 56.6 mm SL.[1]

DISTRIBUTION AND ECOLOGY

Range: Atlantic Coastal Plain from Dismal Swamp, Virginia, to Altamaha River, Georgia; above Fall Line in Mud Creek (a tributary of the Cape Fear) at Durham, North Carolina.[1-4]

Area distribution: Elizabeth and Nansemond Rivers, James River drainage, Virginia;[5] Dismal Swamp, Virginia.[1]

Habitat and movements: Adults—in sluggish streams usually at midstream and frequently associated with aquatic vegetation, in slow, moderate or swift current over bottoms of mud, mud and sand, mud and silt, mud and gravel, silt, sand, detritus, or clay, in both clear or brown water; also recorded from lakes.[1,5,6] Maximum depth, 1.2 m.[6]

Larvae—no information.

Juveniles—no information.

SPAWNING

Breeding tubercles most during late March.[1,3]

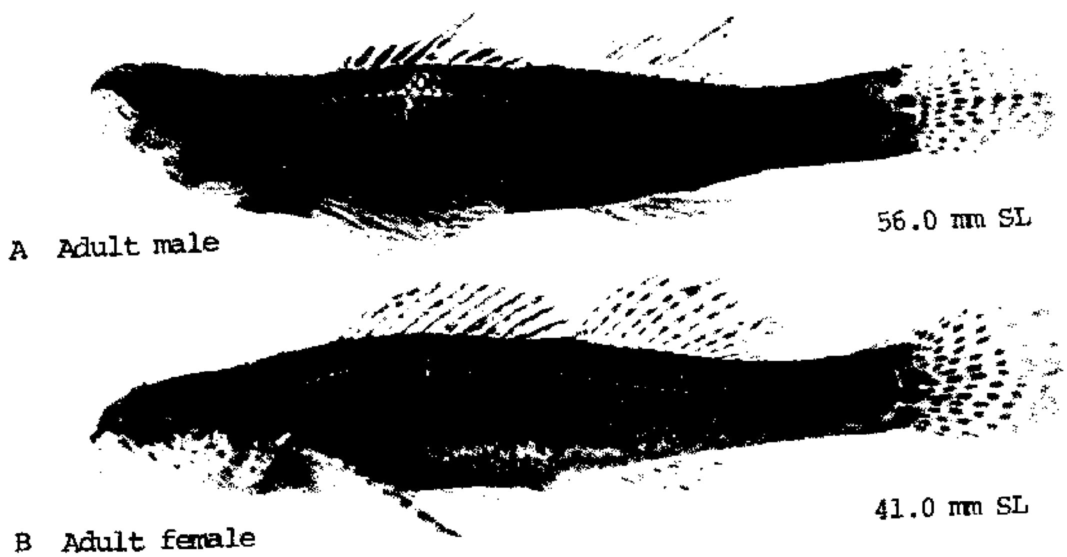

Fig. 180. *Etheostoma serriferum*, Sawcheek darter. A. Adult male, 56.0 mm SL. B. Adult female, 41.0 mm SL. (A, B, Collette, B. B., 1962: fig. 2.)

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

AGE AND SIZE AT MATURITY

Minimum reported length at maturity, males 36.0 mm, female 41.0 mm.[1] Minimum age at maturity, unknown.

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Etheostoma vitreum (Cope), Glassy darter

ADULTS

D. VII to IX, 11–14;[9] A. I–II,[7] 6–9;[9] lateral line scales 47[6]–62;[9] vertebrae 37–39.[2]

Proportions as times in TL: SL 1.16–1.22, snout to end of pectoral fin 2.00–2.19, pectoral fin length 3.50–4.00, HL 8.0–12.0.[3]

Body very slender; maxillary to front of eye. Scales on sides large,[9] and with long apical teeth;[11] belly mostly naked except for few scales between pelvics.[8] Lateral line essentially straight.[7]

Pigmentation: Seven to nine dorsal blotches;[7] a series of small blotches mid-laterally;[8] body translucent in life;[7,8] iris with narrow rim of gold next to pupil.[6] Breeding males very dark,[1] especially on cheeks and venter; head, dorsal, anal, and pelvic fins dark blue.[6]

Maximum length: 51 mm.[8]

DISTRIBUTION AND ECOLOGY

Range: Piedmont and Coastal Plain from Maryland to North Carolina.[7]

Area distribution: Scattered localities in Chesapeake Bay drainage of Maryland and Virginia;[12] in Maryland known only from Anne Arundel, Howard, and Prince Georges counties and considered endangered.[10]

Habitat and movements: Adults—clear sandy streams,[12]

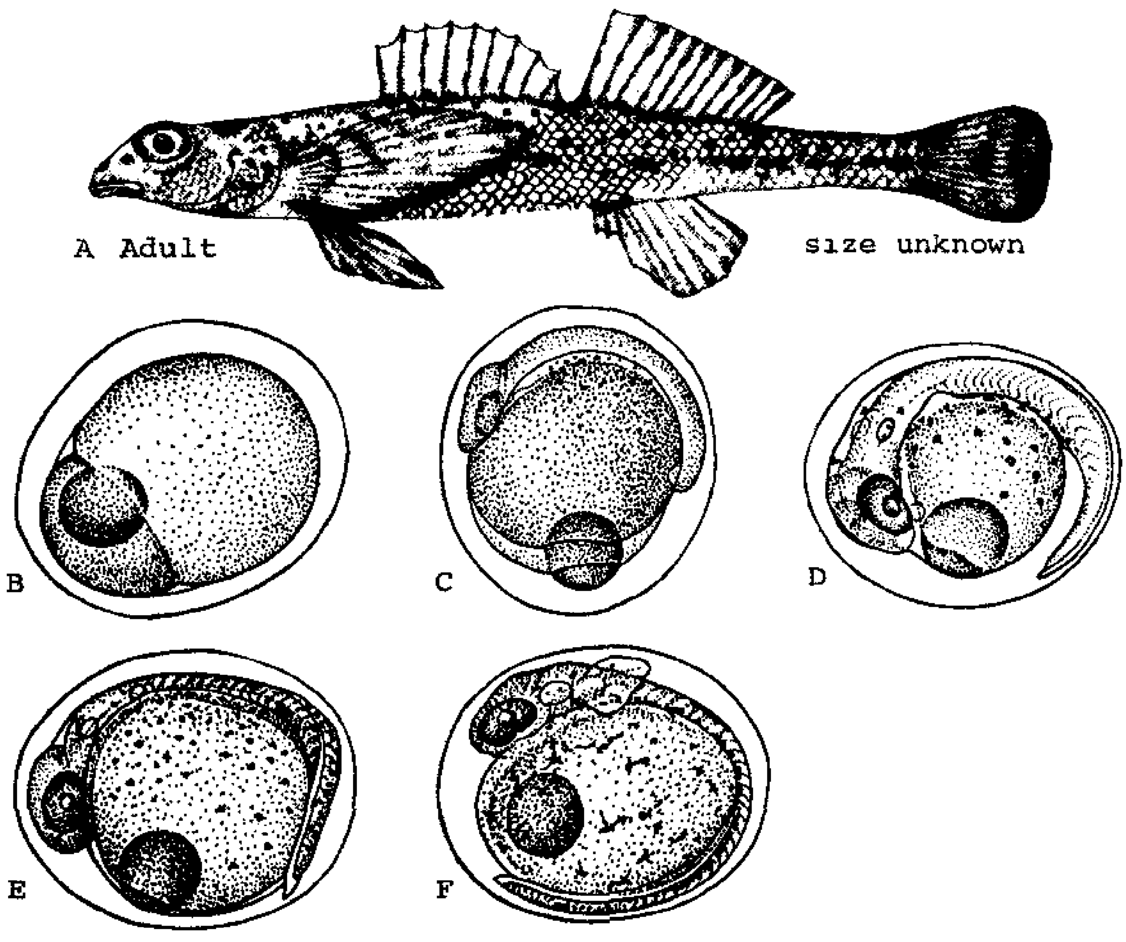

Fig. 181. *Etheostoma vitreum*, Glassy darter. A. Adult, size unknown. B. Early gastrula, 5 days before hatching. C. Early embryo, pigment forming, 4 days before hatching. D. Embryo somewhat more advanced, tail free, age unknown. E. Embryo, 3 days before hatching. F. Pre-hatching embryo, pectoral fins formed. *(A, Schwartz, F., 1964: 10. B, C, E, F, Kennedy, E. R., 1966: figs. 1–4. D, Kennedy, E. R., 1965: fig. 1.)*

sometimes burrowing in the substrate. Appear to move downstream into deeper water in late fall and winter.[1]

Larvae—no information.

Juveniles—no information.

SPAWNING

Location: Spawn communally in streams. Spawning requirements include a fairly rapid current, nearby areas of shifting sand, and a hard surface in the current for egg deposition.[1]

Season: In Maryland over a 3–4 week period from middle of March to April 16;[1] in Virginia observed March 21 to March 30.[5]

Time: In the field observed between 1500 and 1515 hours, in the laboratory between 1254 and 1300 hours and between 1900 and 1905 hours.[1]

Temperature: Occurs at 10–18 C (but up to 19 C in the laboratory).[1]

Fecundity: Average ca. 100,[1] maximum 186.[3]

EGGS

Location: Demersal, aggregated, attached to logs, rocks,[3] or cement walls; aggregates may contain up to ca. 50,000 eggs; eggs may be attached to either undersurface or side of substrate.[1]

Unfertilized eggs: Somewhat ovoid, heart-shaped, and with cluster of many small oil globules.[3]

Fertilized eggs: Adhesive; oblong, 1.42–3.0 mm×1.3–1.7 mm; transparent; yolk amber; yolk diameter 1.0–1.5 mm; oil globule single, diameter 0.3–0.6 mm.[3]

EGG DEVELOPMENT

Development at unspecified temperature:[3]

5 days pre-hatching	blastoderm over about three-fourths yolk, germ ring and embryonic shield evident, yolk constricted in region of blastoderm.
5 days pre-hatching, 1000 hours	caudal and cephalic swellings evident; embryo over about one-half of yolk circumference; eyes barely evident; notochord defined.
4 days pre-hatching, 1100 hours	brain regions evident; some light pigmentation on yolk sac and, apparently on mid-lateral line; Kupffer's vesicle formed.
3 days pre-hatching	tail free; eye well defined; optic cup formed; somites evident.
Late embryo	eye light amber; lens well defined; auditory vesicle formed; pectoral buds and narrow finfold evident, 16–22 somites; additional pigment on head.
Pre-hatching embryo	eyes very black; lens distinct; otoliths and operculum formed; mouth open; nares evident.

Incubation period: 6–9 days at unspecified temperature, with hatching extended over 4 day period.[3]

YOLK-SAC LARVAE

Size range described, 4.7[3]–6.1 mm.[4]

Total myomeres 28–38, $\bar{x}$ 34; preanal myomeres 11–15, $\bar{x}$ 13; postanal myomeres 16–25, $\bar{x}$ 21.[4]

At 4.7 mm yolk sac 1.3 mm, oil globule 0.4 mm.[3] Proportions as times in SL at 4.8 mm SL (5.15 mm TL): Snout-vent length 2.03, HL 5.16.[4]

Body long, slender; yolk mass round at hatching. Yolk mass reduced, oblong by 3rd day. A single nasal opening developed, gill arches forming at hatching; mouth open at 1 day.[4] Incipient rays indicated in ventral portion of caudal region finfold of a 4.8 mm specimen,[3] not so in a larger specimen of 5.3 mm;[4] pectoral fins rayless, large, rounded at 4.8 mm,[3] pointed at 5.3 mm.[4]

Pigmentation: At 4.8 mm lower surface of yolk with double rows of melanophores over vitelline vessels; stellate melanophores between anus and tail; few scattered melanophores in mid-lateral region; and few pigment spots on head.[3] At 5.3 mm pigment over gut and from anus to tip of tail ventrally; pigment on yolk sac somewhat increased; a few conspicuous mid-lateral chromatophores; and scattered chromatophores on head.[4]

LARVAE

Size range described, 6.0–9.8 mm.

Total myomeres 33–37, $\bar{x}$ 35; preanal myomeres 11–16, $\bar{x}$ 14; postanal myomeres 20–23, $\bar{x}$ 21.[4]

Proportions as times in SL at 6.1 mm SL (6.47 mm TL): Snout-vent length 1.36, HL 4.41.[4]

Caudal fin rays evident above and below urostyle, pectoral fin rays well-developed at 6.0 mm; all median fins and pelvic fins developing at 9.8 mm. Urostyle flexed at 9.8 mm.[4]

Pigmentation: At 6.0 mm ventral pigment as in previous stage; pigment on head increased; scattered chromatophores along dorsal surface. At 9.8 mm pigment barely evident over gut, no ventral pigment between anus and tail; a row of melanophores mid-laterally from region

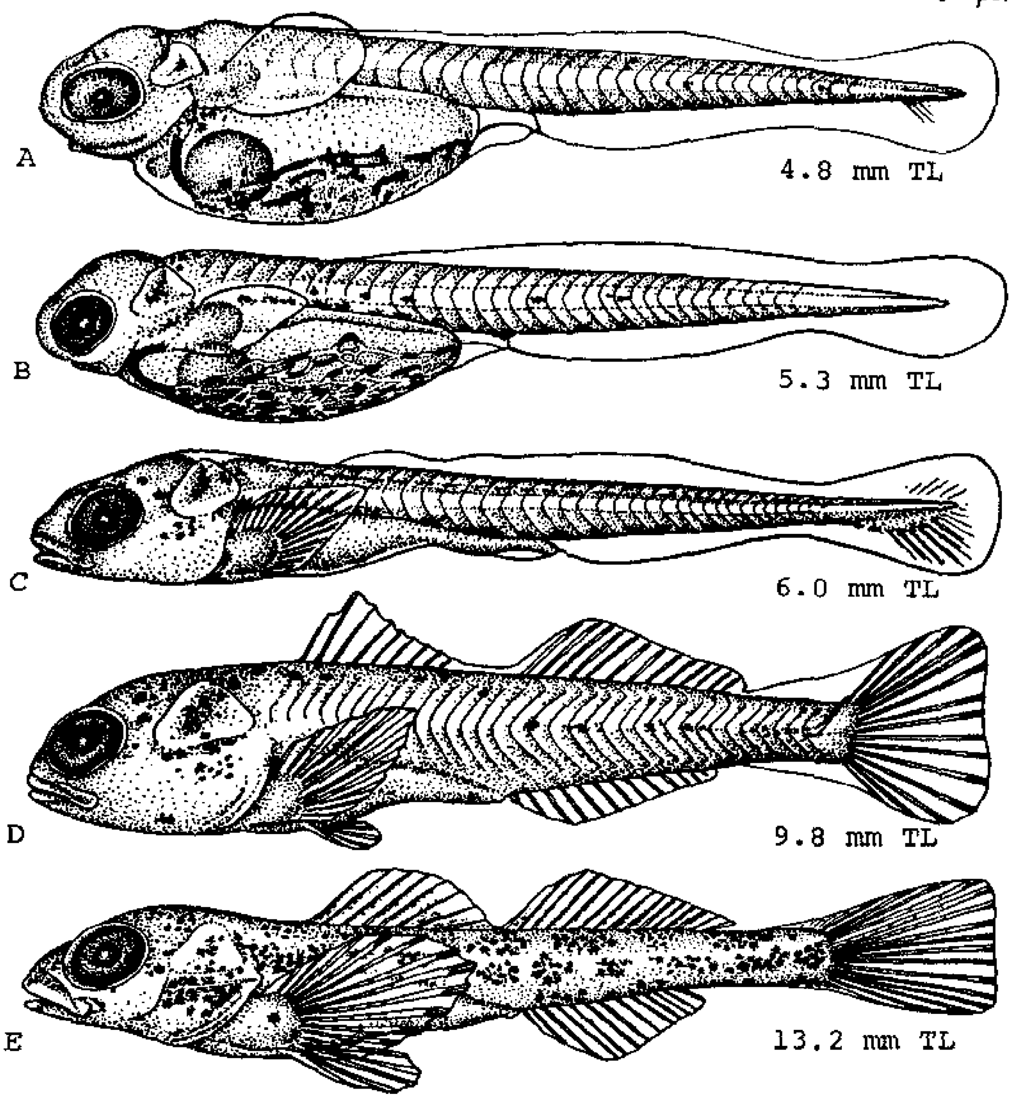

Fig. 182. *Etheostoma vitreum*, Glassy darter. A. Yolk-sac larva, 4.8 mm TL. B. Yolk-sac larva, 5.3 mm TL. C. Larva, 6.0 mm TL. D. Larva, urostyle flexed, 9.8 mm TL. E. Juvenile, 13.2 mm. (*A, Kennedy, E. R., 1966: fig. 5. B-E, Kennedy, E. R., 1965: figs. 2–5.*)

above and just behind anus to tail; an indefinite row of scattered melanophores dorsally over anterior part of body; pigment on head and cheeks greatly increased.[4]

JUVENILES

Maximum size described, 13.2 mm.

At 13.2 mm body much more slender than in previous stage.[4]

Pigmentation: At 13.2 mm entire body covered with groups of stellate melanophores; pigment developed in dorsal, anal, caudal, and pectoral fins; a prominent melanophore on pectoral base.[4]

AGE AND SIZE AT MATURITY

No information.

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Perca flavescens (Mitchill), Yellow perch

ADULTS

D. XII [18] to XV [44]–I [18] to II,[44] 12 [18]–15; A. II,[1] 6–8; [68] C. 19; [64] P. 15; V. I, 5; [9] scales in lateral line 51 [68]–62,[1] in transverse series ca. 25,[6] on cheek ca. 13; [9] trunk vertebrae 16–22; caudal vertebrae 20–22; total vertebrae 38 [68]–42; [2] gill rakers on lower limb 12–16, on upper 4–8; branchiostegals usually 7, sometimes 6 or 8; [68] pyloric caeca 3.[64]

Proportions as times in TL: Depth 3.0 [64]–4.3,[67] head 3.1 [7]–3.4.[18] As percent TL: depth 16.3–28.1, head 23.1–29.3. As percent HL: eye 15.8–30.4 but including "young"), jaw 23.4–34.2, interorbital distance 16.9–27.3.[68]

Body fusiform, moderately elongate [9] and compressed; [7] back very convex; [18] head acutely pointed, its profile concave; [5] mouth slightly oblique, terminal; [7] gape extended approximately to middle of eye.[9,68] Teeth small, in villiform bands on mandibular, maxillary, vomer, and palatine bones, canines lacking.[63,64] Lateral line complete,[7] prominent, curved upward.[9,68] Spinous dorsal fin noticeably higher than soft dorsal.[44]

Pigmentation: Bright green,[68] olive,[1] or golden above,[68] the dorsal pigment extending down over sides in 5–9 [44] tapering bars [68] which fade ventrally; [63] sides typically yellow-green, yellow,[68] or golden yellow,[63] sometimes gray or blackish,[18] and sometimes with coppery, reddish, or purplish wash; [15] ventral surfaces yellow, orange,[1] gray, or milk-white. Eye yellow to green. Dorsal fin yellow to green, and usually with two black blotches, one posteriorly on last four spines and a smaller one anteriorly between first two spines; anal fin yellow to silver white; caudal fin yellow to green; pectorals amber, transparent; pelvics yellow to silver-white, sometimes tinged with red. Body rarely gray-blue or red and lacking bars. Spawning males with body colors more intense and lower fins orange or bright red.[63,68]

Maximum length: Ca. 356 mm.[15]

DISTRIBUTION AND ECOLOGY

Range: Along Atlantic coast from Nova Scotia to South Carolina; west of Appalachian Mountains from western Pennsylvania southwestward to northern Missouri and eastern Kansas, then northwest to Montana and, in Canada, to Great Slave Lake; southeast from northern Canada to James Bay, Quebec, and New Brunswick.[68] Now widely introduced. Specifically recorded from Georgia,[53] western Florida, Alabama, Texas [68] (although apparently not surviving there [8]), New Mexico, Utah,[68] Oklahoma,[4] Nevada,[64] California, Oregon, and Washington. Now occurs in British Columbia as a result of spread from introductions in Washington state.[68]

Area distribution: Found in coastal waters adjacent to Chesapeake Bay in Maryland and Virginia; [7,52,66] also region of Sinepuxent and Chincoteague bays on Atlantic coast of Maryland and Virginia; [62] Delaware; [73] New Jersey.[74]

Habitat and movements: Adults—a schooling species [16] typically found over bottoms of muck, sand, and gravel,[68] but sometimes concentrated in the epilimnion,[6] or in schools at surface.[35] Recorded from lakes, ponds, and swamps, and quiet parts of rivers and streams; [15,33,68] sometimes associated with aquatic vegetation such as pondweed (*Potomogeton*). Large individuals typically in deeper water,[48] and sometimes move into anoxic water to feed.[46] Remain active under ice in winter; [29] also in winter schools less compact than in summer.[28] Maximum recorded depth 256 m, but fish in poor condition; [6] otherwise maximum depth 45.7 meters; [68] typically at depths of less than 27 [51] to 45.7 m. Recorded natural temperature range 6.7 [48] to 25.0 C,[30] vertical movements suggesting that they follow the 20 C isotherm; [68] upper lethal temperature ca. 26.5 [30]–33.0 C.[63] Maximum recorded salinity 12.94 ppt,[3,87] but also recorded in water having bottom salinity of 15.0 ppt and surface salinity of 6.0 ppt, and in saline lakes having 10,300 ppm dissolved solids (salt composition not stated).[68]

Prespawning inshore or upstream migrations begin in Maryland in late February and March,[40,46] in Wisconsin following the breakup of ice in April or early May,[37] and in Michigan in late May.[6] Males arrive on the spawning grounds before females and stay longer, the females remaining only long enough to spawn; [35,39,64] after spawning, in the Severn River, Maryland, disperse downstream, but remain in river.[45,59] Diurnal movements occur, with schools moving both upward [64] and inshore at night.[63] These movements occur at sunrise and sunset and the fish remain inactive at night.[34] There is a general tendency to move to deeper water in winter.[6,41,58,63]

Larvae—typically limnetic,[17] pelagic,[11] and photopositive; [31,43] in schools in shallow water,[12] also in open water and subject to dispersal by wind-induced currents.[10] Most abundant at or near surface,[43] but maximum recorded depth 18 m; [55] specimens 8–20 mm long primarily in upper 6 m; during calm conditions concentrated in upper 1.5 m; in winds over 19 kph, concentration shifted to between 1.5 and 6 m.[47] Reported from 10–19 C; with survival best between 16 and 19 C.[26]

Juveniles—move in large schools; [35,40] initially pelagic, becoming demersal at ca. 25 mm; [70] young ca. 25–50 mm long inshore from deeper water in July; [48] at ca. 50 mm common on shoals, associated with aquatic vegeta-

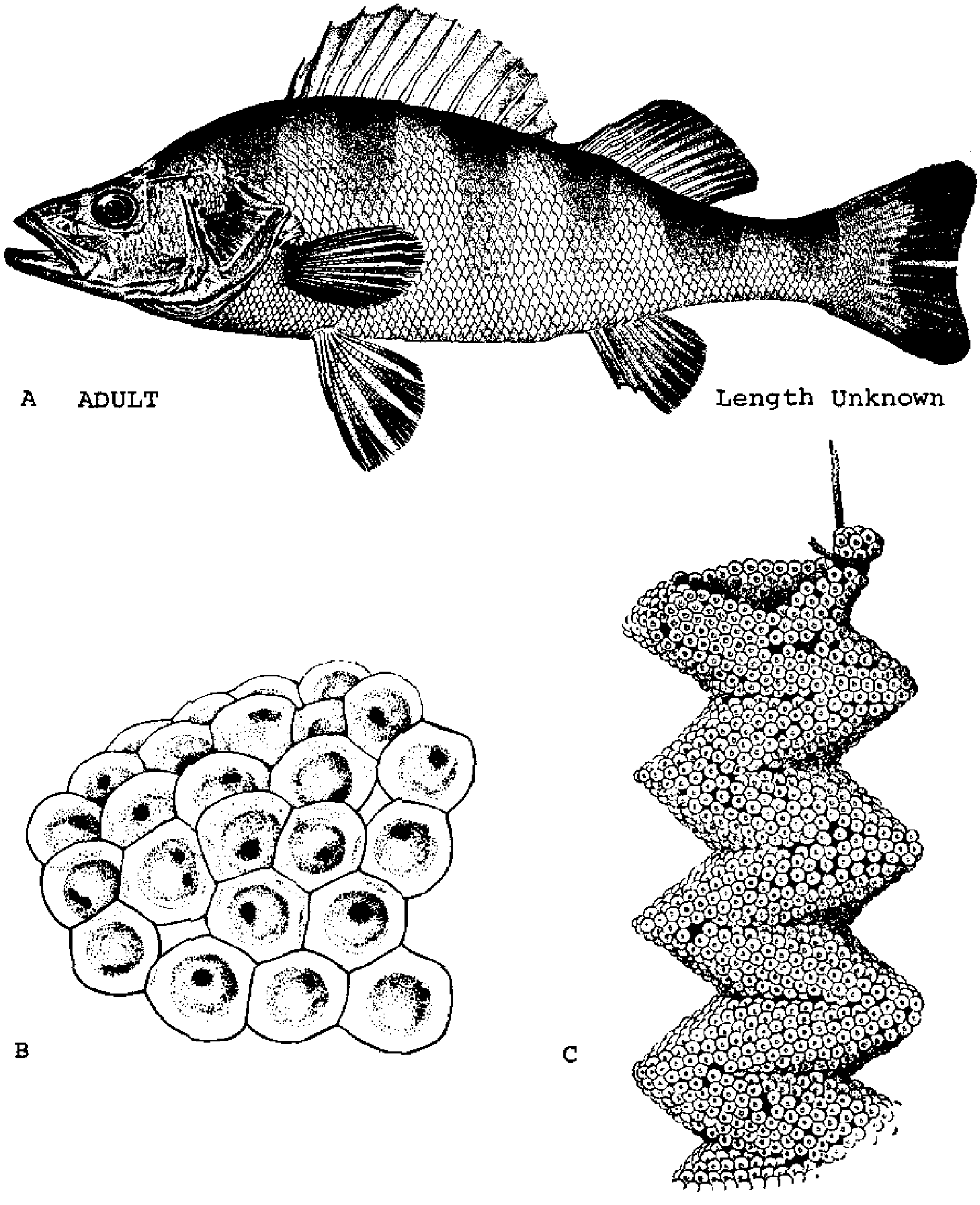


Fig. 183. *Perca flavescens*, Yellow perch. A. Adult, length unknown. B. Cluster of unfertilized eggs. C. Section of an egg mass. (*A, Goode, G. B.,* et al., *1884: pl. 168. B, Mansueti, A. J., 1964: fig. 7. C, Worth, S. G., 1892: pl 61.*)

tion.[67] Specimens up to 110 mm long aggregate with young spottail shiners, *Notropis hudsonius*.[61] Depth range, variously recorded from surface to 31 m.[6,27,55] Salinity range 0.5–9.5 ppt.[40]

SPAWNING

Location: Near shore [12,48,64] in lakes [35,49,50] and rivers [40] over bottoms of rock,[6] sand,[64] gravel,[37] or rubble,[63] also, sometimes, over aquatic vegetation; [38] in association with submerged brush, weeds, roots, and fallen trees; [25,68,69] or in areas of cattails or water willows; [49,50] typically spawn at depths of 1.5–3 m.[37,63] and never deeper than 15 m.[6] In Chesapeake Bay region in both tidal and nontidal water.[54]

Season: In North Carolina begins in February; [5] in Potomac River in March and April; [15] in Maryland appear on spawning grounds as early as February 22,[54] eggs observed as early as March 1,[25] peak activity around mid-March; [54] in New York mostly in April and May; [12,48] in New Hampshire mid-April; [60] in Illinois in April; [23] in Wisconsin ripening females in November, actual spawning in April and May; [35,42] in Minnesota May, with spawning lasting 2–4 weeks; [48] in Lake Ontario first of May to end of June; [37] in California eggs and ripe fish from late March to mid-May.[12] In northern localities spawning may continue into July.[68]

Time: Usually at night,[1,12,64] but observed during daylight hours both in the field [60] and laboratory.[14,38]

Temperature: 5.0 [46]–12.8 C [33] (but in laboratory as high as 14 C [38]); peak at 8.5–11.0 C (based on surface temperatures).[38]

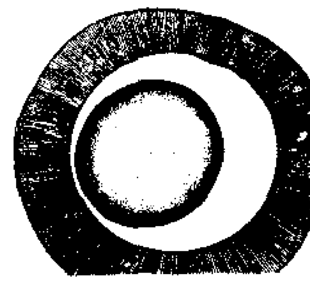
Maximum salinity: 2.5 ppt.[40]

Fecundity: Overall range 2000 [14,68]–109,000,[40] based on number of eggs in a single egg mass 7000–138,000; [20] average estimate at 23,000; as related to age, age group II+ fish (131–195 mm FL) 3035–18,276, $\bar{x}$ 10,513, age group VIII+ (257 mm FL) 61,465; [37] as related to weight, at 0.34–0.40 kg 44,000–48,000.[12] Three distinct sizes of eggs are evident in the ovaries at one time.[37]

EGGS

Location: Deposited in long, flat, demersal,[21] semibuoyant,[65] or, rarely, floating bands or ribbons [21] among vegetation such as reeds, canes,[52] bushes, weeds,[26] willow roots,[35] tules,[12] and branches of birch trees; [60] also on stones,[35] gravel and mud.[49,50] Egg masses sometimes stranded by receding tides,[46] washed or blown ashore,[19,22,68] or stranded out of water as in tree limbs.[13,23]

Egg masses: Eggs are deposited in a single layer in long,[58] tough,[14] gelatinous,[14,52] hollow ribbons.[1,12] The ribbons are light gray,[14] translucent [9] or transparent,[48] nonadhesive,[1] and arranged in transverse folds like bellows. They are bluntly forked at one end,[15] closed at both ends, and possess an internal passage with occasional openings to the outside. These openings are thought to be involved in aeration of the eggs.[12,14,68] The ribbons, when first deposited, correspond almost exactly with the shape of the ovarian cavity [24] and are relatively small (ca. 20–30 cm long).[9] After water hardening they are much larger, reaching maximum lengths of 2.1–2.4 m [1,5,35,37,57] and widths of 3.8 [54] to 10.1 cm.[14]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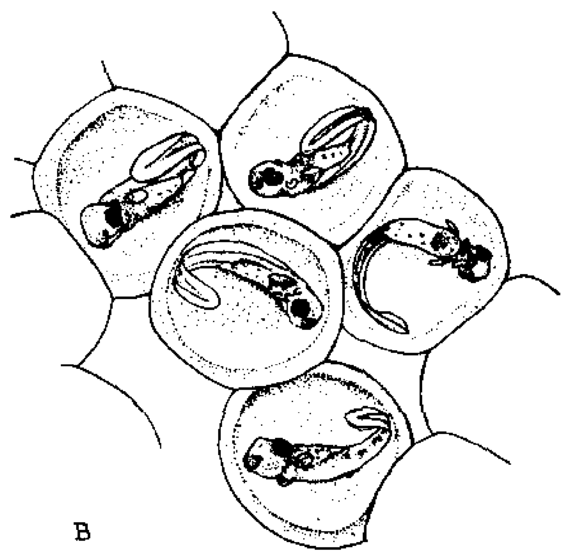

B

Fig. 184. *Perca flavescens*, Yellow perch. A. Unfertilized egg showing micropyle and thick chorion. B. Cluster of eggs just prior to hatching. (*A, Ryder, J. A., 1887: pl. 8. B, Mansueti, A. J., 1964: fig. 4.*)

Unfertilized eggs: Diameter ca. 1.5 mm; oil globule indistinct, dark yellow; yolk pearly white.[54]

Fertilized eggs, nonwater-hardened: Diameter 1.50 [21]–2.81 mm,[54] averages variously stated at 1.73,[21] 1.76, and 2.26; yolk light amber; chorionic striations evident; egg surface with minutely pebbled texture.[54]

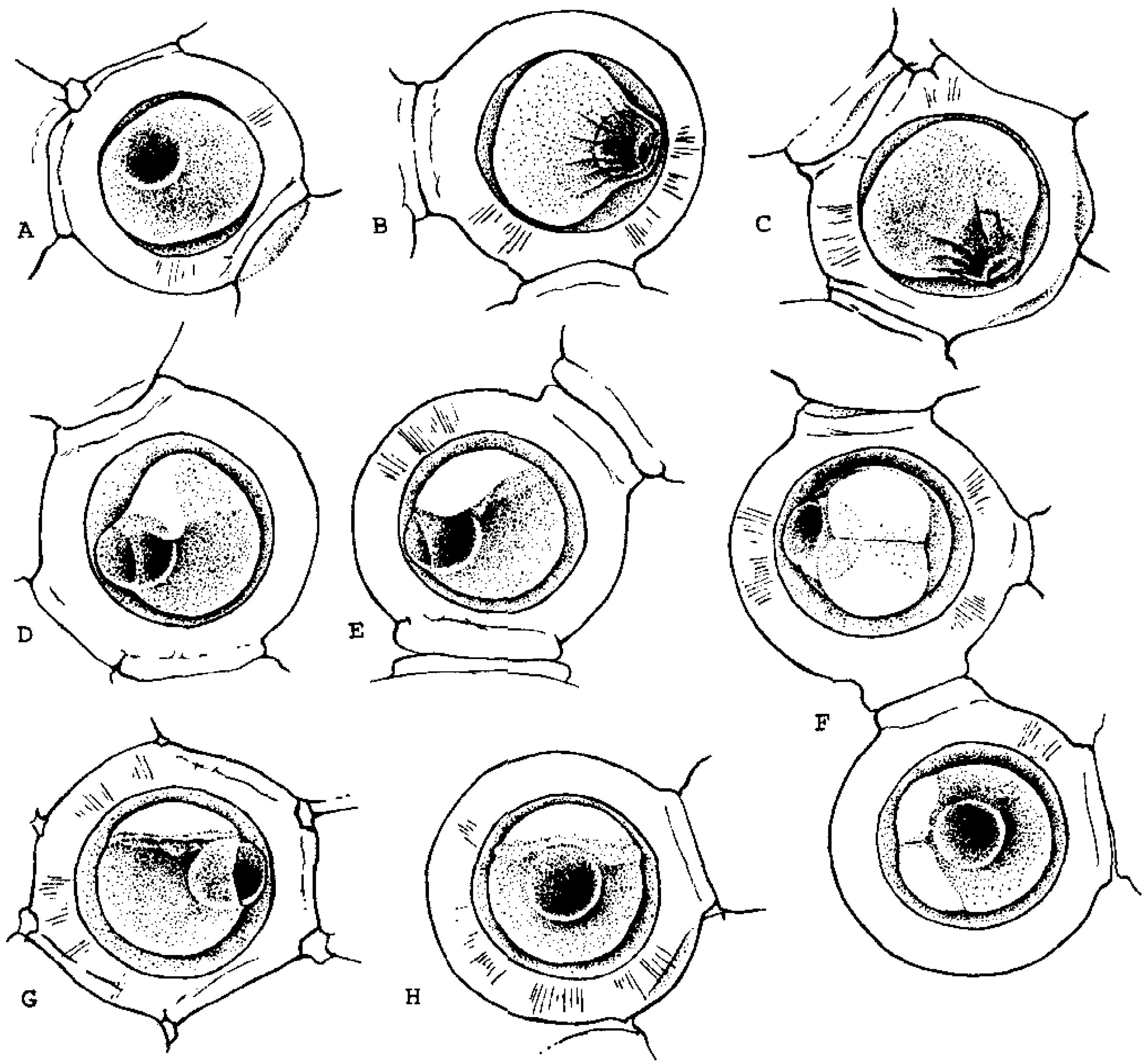


Fig. 185. *Perca flavescens*, Yellow perch. A-H. Development of eggs. A. Egg at time of fertilization. B. Just prior to blastodisc formation, 14 minutes. C. Blastodisc, 32 minutes. D. Blastodisc, 47 minutes. E. Blastula, 4 hours, 24 minutes. F. Two-cell stage, 5 hours, 14 minutes. G. Early gastrula, 21 hours, 25 minutes. H. 29 hours, 9 minutes. (*A-H, Mansueti, A. J., 1964: fig. 8.*)

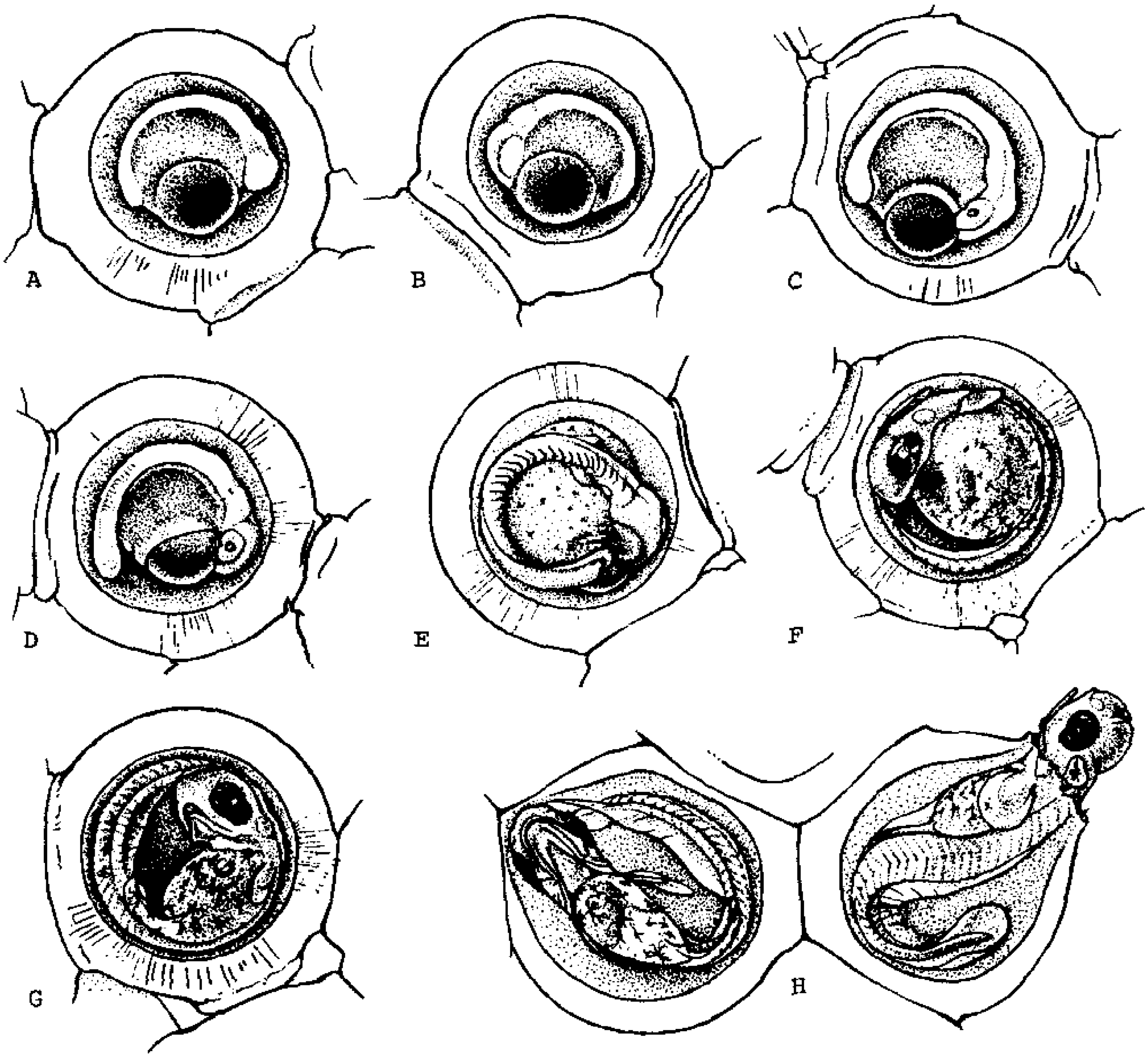


Fig. 186. *Perca flavescens,* Yellow perch. A-H. Development of eggs (continued). A. Early embryo, 69 hours, 54 minutes. B. Embryo, eyes clearly forming, 77 hours. C. Lens formed, 115 hours. D. Tail-free stage, 144 hours. E. Pectoral buds evident, myomeres forming, 11 days. F. Eyes pigmented, 16 days. G. Embryo just prior to hatching, mouth open, yolk one-half absorbed, 24 days. H. Hatching, 27 days. *(A-H, Mansueti, A. J., 1964: fig. 9.)*

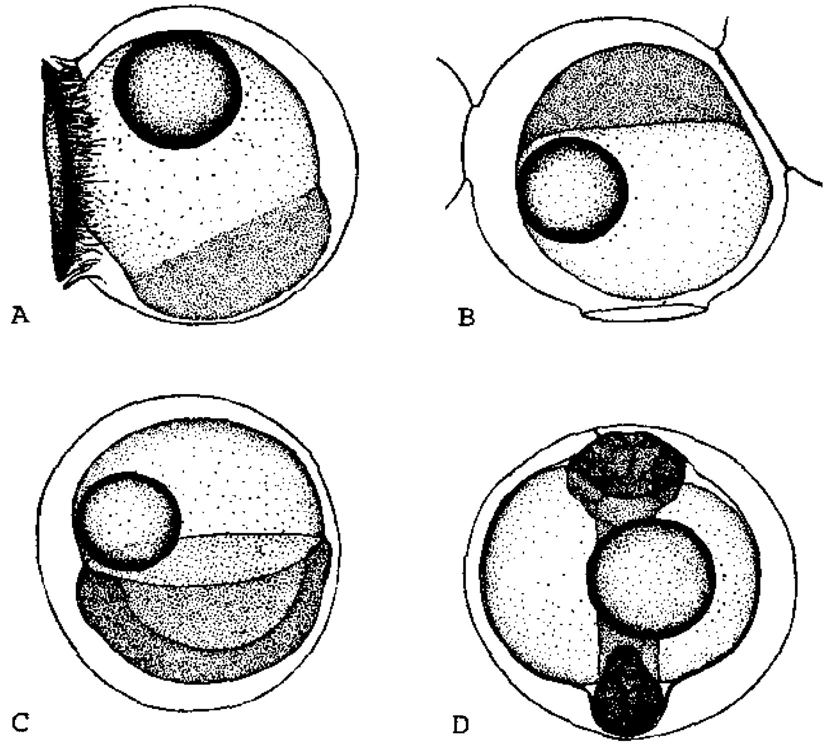


Fig. 187. Perca flavescens, Yellow perch. A-D. Several views of developing eggs. A-B. Blastodisc formation. C. Embryo over one-half of yolk. D. Advanced embryo. (*A-D, Ryder, J. A., 1887: pl. 8.*)

Water-hardened fertilized eggs: Diameter variable and tending to decrease during first 2 weeks of development and increase 2 weeks prior to hatching,[54] overall range 1.72 [21] to average of ca. 4.5 mm [54] (greatest diameter apparently unrecorded, JDH), clear amber and brilliant,[54] *or light and semi-transparent;* [15,27] chorion nonadhesive, thick, hyaline [21] and with three layers, the middle of which is striated and noticeably thick; [56] yolk diameter 1.15 [21]–1.75 [27] *with averages stated as* 1.28 [54] *and* 1.38 mm; [21] oil globule yellow,[36] single, diameter 0.35 [21]–0.92 mm,[54] averages stated as 0.54 [21]–0.64 mm.[54]

EGG DEVELOPMENT

Development at unspecified temperature: [54]

At 14 minutes	oil globule shifted to one side of yolk mass, pulling yolk material with it so that distinct "tension lines" are evident.
At 32 minutes	germinal thickening evident in area just above oil globule.
At 47 minutes	blastodermal tissue formed into distinct peak at one side of yolk.
At 4 hours	blastodisc flattened over yolk.
At 5 hours, 14 minutes	two-cell stage.
At 21 hours, 25 minutes	germ ring, blastocoel developed.
At 29 hours, 9 minutes	germ ring over one-third of yolk.
At 69 hours, 54 minutes	embryo well-developed, head differentiated.
At 77 hours	eye, brain divisions, and probably, Kupffer's vesicle developed.
At 115 hours	*lens evident in eye, choroid fissure formed.*
At 144 hours	tail-free stage, somites evident.
At 11 days	*somites greatly increased;* otocysts, pectoral buds formed, pigment on yolk.
At 14 days	mouth open, primitive gill structures formed, eyes pigmented, tail extended over head.
At 16 days	eyes pigmented, pectoral fins elongate.
At 24 days	mouth open, yolk half absorbed, otoliths evident.

At 27 days	hatching.[54]

Mansueti noted that advanced embryo had about 33–36 somites.[21] A description of development from blastodisc to stage having blastoderm "almost to equator of egg"[60] in 2 hours, 45 minutes is questioned (JDH).

Incubation period:

At 5.4 C	50% total hatch in 51 days.[71]
At 8.3 C	27 days.[1,27,48]
At mean of 9.6 C	average 20 days.[46]
At 15 C±3 C *(salinity 0.0 ppt)*	ca. 11–13 days.[72]
At 15 C±3 C (salinity 5.8 ppt)	ca. 13–15 days.[72]
At 18 C	ca. 8–11 days.[72]
At 19.7 C	50% total hatch in 6 days.[71]
At temperatures that varied from 2–15 C	*ca. 18–20 days.*[72]

Hokanson and Kleiner noted that the duration of hatching varied from 2 days at 18.2 C to 30 1/2 days at 3.3 C. At lower temperatures hatching was premature and, at 3.2 C, occurred before the heartbeat was established.[71]

YOLK-SAC LARVAE

Hatching *length 4.7–6.6 mm,*[71] *average 5.80; yolk ab*sorbed at 5.6–7.5 mm, average 6.7 mm;[21] feeding began at minimum of 3 days;[13] maximum age at end of stage ca. 5 days.[27,68]

Myomeres 17–22[21] + 16–21,[68] totals of 34–42 reported. Five to 8 myomeres between end of yolk and anus.[21]

Snout-vent length 52, head length *ca.* 17 percent TL.[54] At 5.5 mm, length to vent 2.7 mm, greatest depth 0.83 mm, eye 0.36 mm.[27] At 5.6 mm, length to vent 2.75 mm, greatest depth 0.93 mm, HL 0.75 mm. At 7.3 mm, length to vent 3.6 mm, greatest depth 0.95 mm.[55]

At hatching body elongate;[21] yolk sac relatively small, ovate;[33] oil globule large, anterior;[54] head rounded,[55] *separated from yolk;*[54] mouth open,[21] *lower jaw not well*developed.[54] At 7.3 mm mouth terminal, slightly below midline of body;[56] teeth present by end of stage,[21] choroid fissure retained.[54]

Pectorals well-developed, rayless at hatching;[27] rays apparently forming at 7.2 mm.[54] Finfold granular in appearance;[27] dorsal finfold origin over first myomere, and its edge essentially straight to caudal; gut straight from posterior margin of yolk to anus.[32]

Pigmentation: Body transparent; pigment on eye, oil globule, yolk sac, *and ventral edge of trunk.*[21] At ca. 5.5–5.6 mm eyes dark; large, light-colored chromatophores sparsely distributed on ventral part of yolk sac; usually one or more chromatophores on dorsal and ventral aspects of intestine; unevenly distributed chromatophores ventrally behind anus and following myosepta from ventral margin to lateral line.[27,55] At 5.75 mm pig*ment similar to previous stage*, but with *15–20* pigment spots in definite row along ventral ridge of tail. At 7.2 mm pigment developed on posterior part of head, several scattered melanophores on lower sides of body.[54] In a specimen 7.3 mm long, chromatophores on ventral aspect *of yolk in an irregular, double row, postanal pigment* as previously described, 2 chromatophores on intestine at anus.[55]

LARVAE

Size range described, 5.6[21]–21.7 mm.[54]

Myomeres 17–22 + 16–21.[21,32]

Snout-vent length generally 45–56% TL;[21] at 20 mm HL ca. 27% TL.[54] At 9.0 mm, length to vent 5.0 mm, greatest depth 1.04 mm. At 12.5 mm, length to vent 6.2 mm, *greatest depth 2.1 mm.*[55] *At 20.5 mm, length to vent* 10.5 mm, length to dorsal 5.95 mm, greatest depth 3.6 mm.[27] At 20.5 mm body greatly compressed, more elongate than in adult. Gape extended to middle of eye;[27] at 8.3 mm teeth present on premaxillaries;[32] indications of choroid fissure throughout stage; preopercular spines *evident at 14.2 mm;*[54] *ossification of branchiostegals be*gun at 9.0–10.0 mm. Finfold essentially gone at 13.0 mm,[32] but preanal finfold still evident at 14.2 mm.[54] Dorsal rays developed at 12–13 mm,[32] spines at 14.4 mm;[55] anal rays formed over size range of 12[32]–15 mm;[21] *incipient caudal rays first evident at 8.0–8.7 mm;*[54] *pec*toral rays beginning to ossify at 13–14 mm;[32] pelvic fins first evident at ca. 13[21]–14 mm,[55] ossified at 15–16,[32] well-developed at 20.5 mm.[27] Vertebral ossification evident at 9–10 mm;[32] urostyle oblique at ca. 12–13 mm;[21] scale pockets evident on caudal peduncle at ca. 20 *mm.*[55] Intestine initially straight,[32] at 8.7 mm folded back on self,[54] coiled at 12.5 mm.[55] Gas bladder well formed at 8.7 mm, at 14.2 mm extremely large.[54]

Pigmentation: At 7.2 mm pigment increased over head and jaws, a dashed line of melanophores mid-laterally. At 8.7 mm pigment along ventral line in regularly spaced *series, gas bladder pigmented above, few stellate chro*matophores over gut.[54] At 12.5 mm few chromatophores around both jaws and on top of head, few on opercle, a subsurface group over stomach region, and a single large chromatophore on ventral aspect of gut midway to vent *(otherwise as in previous stage).*[28] At 20.5 mm chromatophores on top of head and in double line dorsally to end of body; also on sides of head and more or less evenly on sides of body; an indistinct row of large stellate chromatophores to vent and an irregular double series from vent to caudal, darkest at base of anal; dorsal, anal, and caudal speckled.[27] At 21.7 mm banding along back.[54]

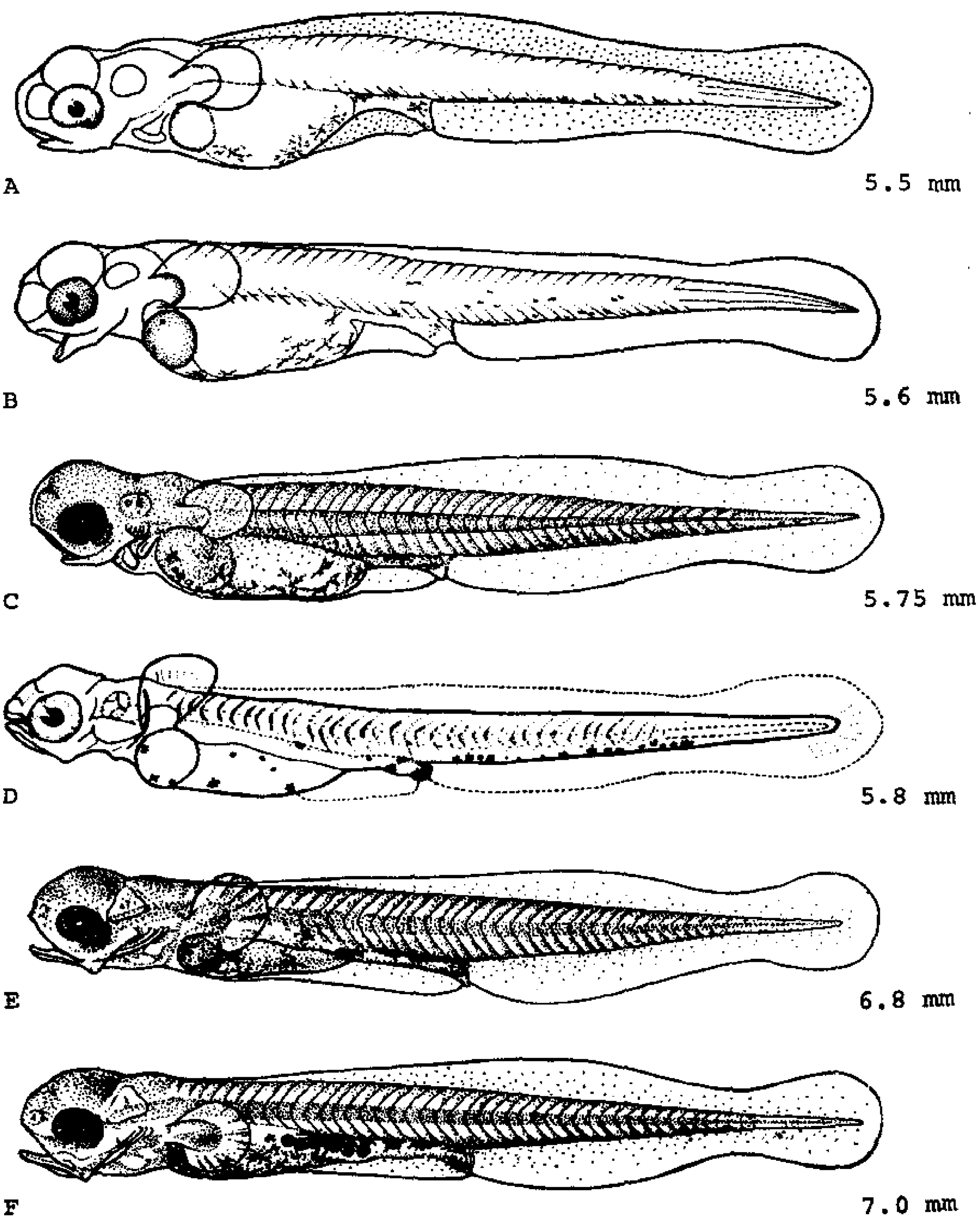


Fig. 188. *Perca flavescens*, Yellow perch. A. Yolk-sac larva, 5.5 mm TL, mouth open. B. Yolk-sac larva, 5.6 mm TL. C. Yolk-sac larva, 5.75 mm TL, pigment increased on yolk and ventrally posterior to tail. D. Yolk-sac larva, 5.8 mm TL. E. Yolk-sac larva, 6.8 mm TL. F. Yolk-sac larva, 7.0 mm TL. (*A, Fish, M. P., 1929: fig. 17. B, Fish, M. P., 1932: fig. 84. C, E, F, Mansueti, A. J., 1964: fig. 10. D, Norden, C. R., 1961: fig. 1.*)

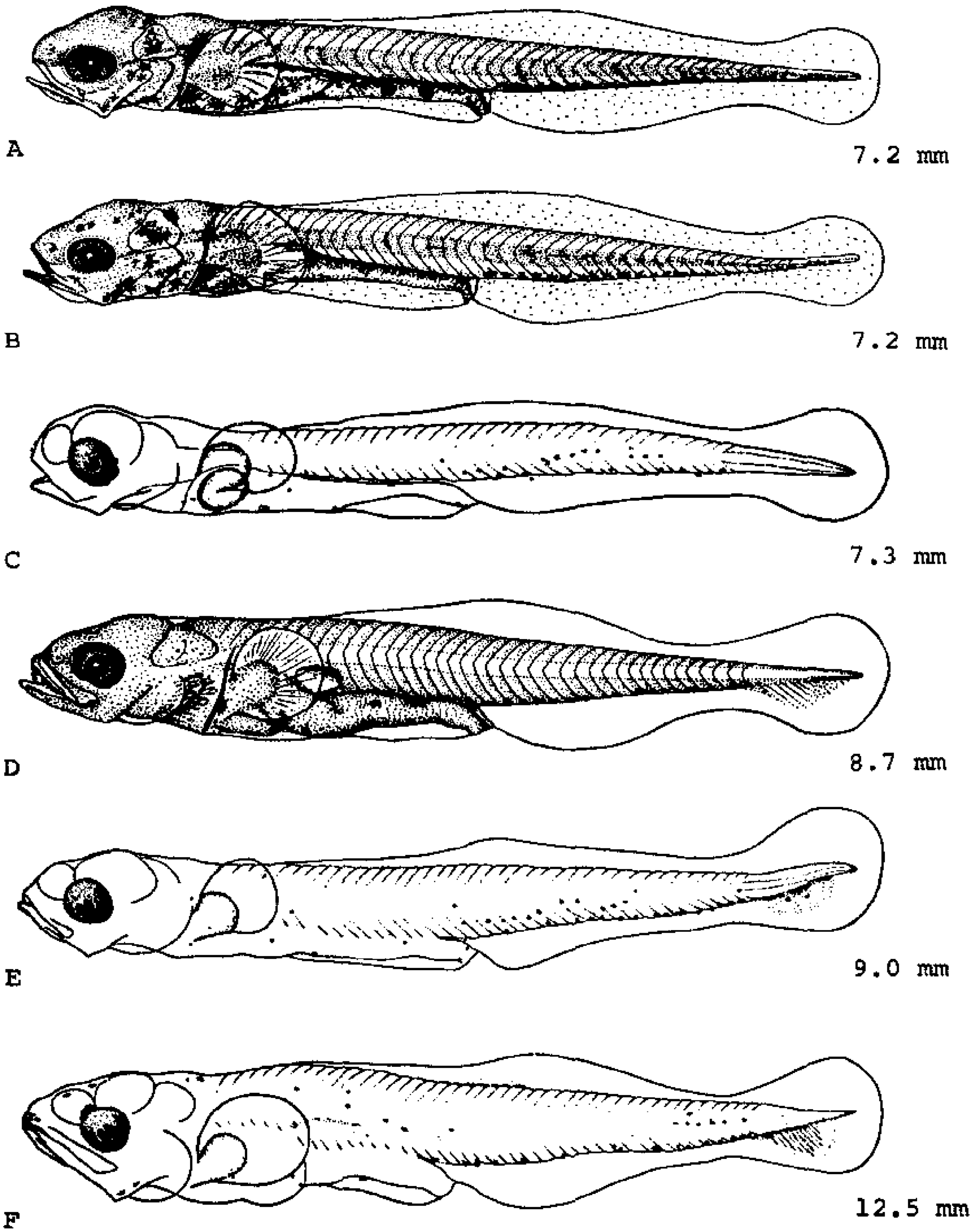


Fig. 189. *Perca flavescens*, Yellow perch. A. Yolk-sac larva, 7.2 mm TL. B. Larva, 7.2 mm TL. C. Larva, 7.3 mm TL. D. Larva, 8.7 mm TL. E. Larva, 9.0 mm TL. F. Larva, 12.5 mm TL. (*A, B, D, Mansueti, A. J., 1964: figs. 10, 12. C, E, F, Fish, M. P., 1932: figs. 85–87.*)

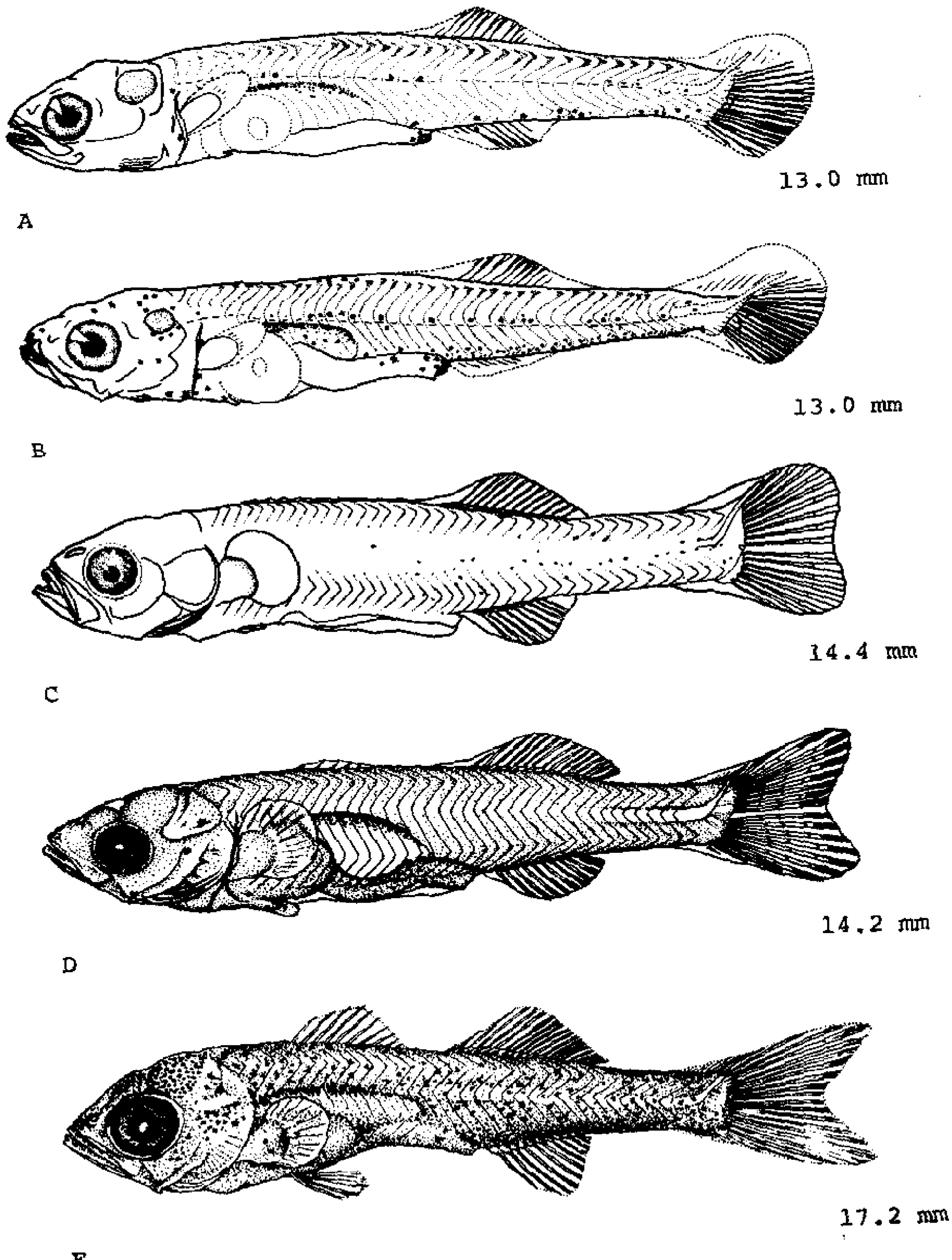


Fig. 190. *Perca flavescens*, Yellow perch. A. Larva, 13.0 mm TL, urostyle oblique, vertical fin rays forming. B. Larva, 13.0 mm TL, pigment increased on body. C. Larva, 14.4 mm TL, spinous dorsal, pelvic fins barely evi-

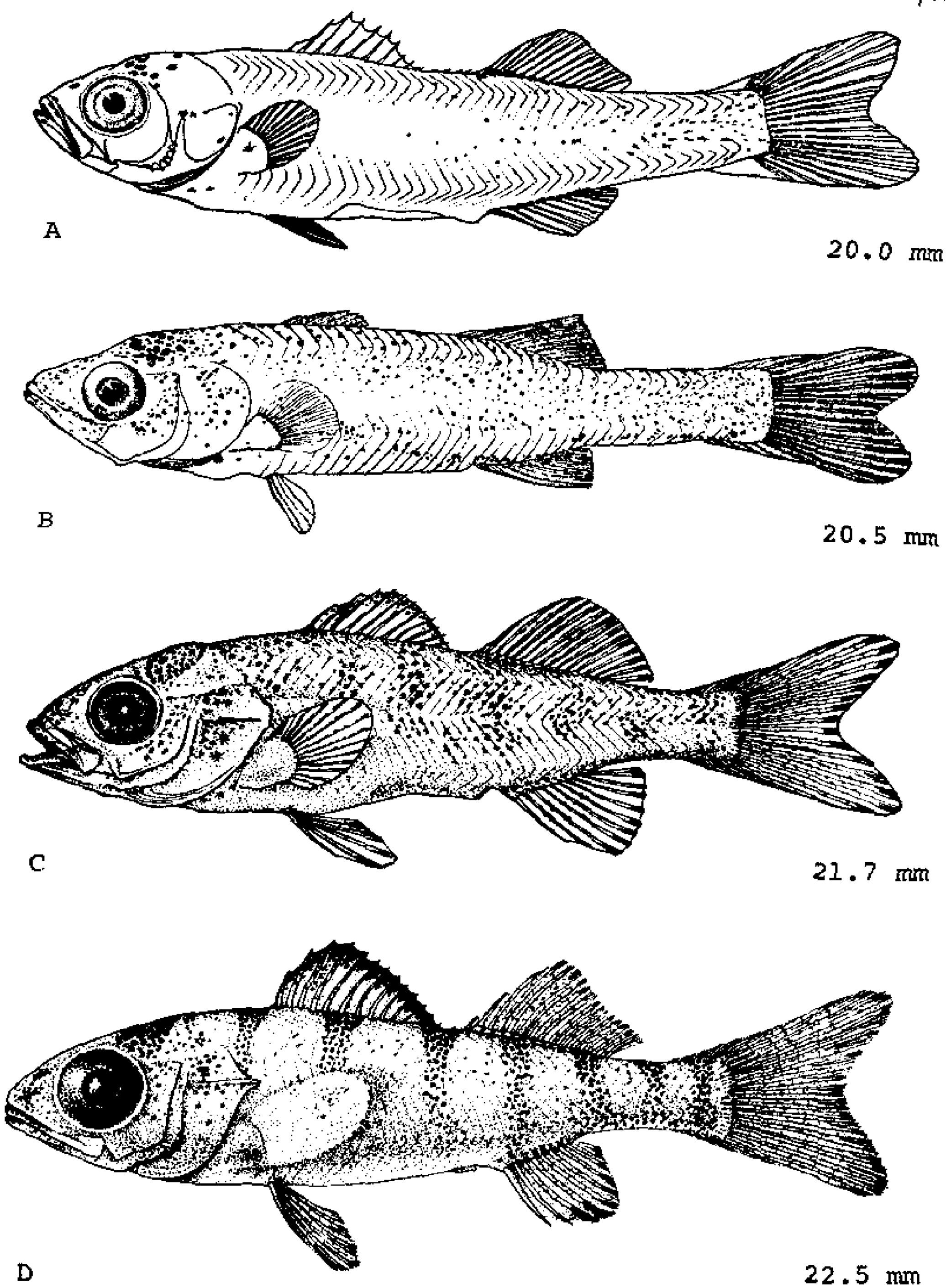


Fig. 191. *Perca flavescens*, Yellow perch. A. Early juvenile, 20.0 mm TL. B. Juvenile, 20.5 mm TL, pigment noticeably increased. C. Juvenile, 21.7 mm TL, lateral pigment bars beginning to develop. D. Juvenile, 22.5 mm TL. *(A, B, Fish, M. P., 1932: figs. 89–90. B, Mansueti, A. J., 1964: fig. 12. C, Original drawing, A. J. Lippson.)*

dent. D. Larva, 14.2 mm TL, slightly smaller than previous specimen, but noticeably more advanced. E. Advanced larva, 17.2 mm TL. *(A, B, Norden, C. R., 1961: figs. 2–3. C, Fish, M. P., 1932: fig. 88. D, Mansueti, A. J., 1964: fig. 12. E, Original drawing, A. J. Lippson.)*

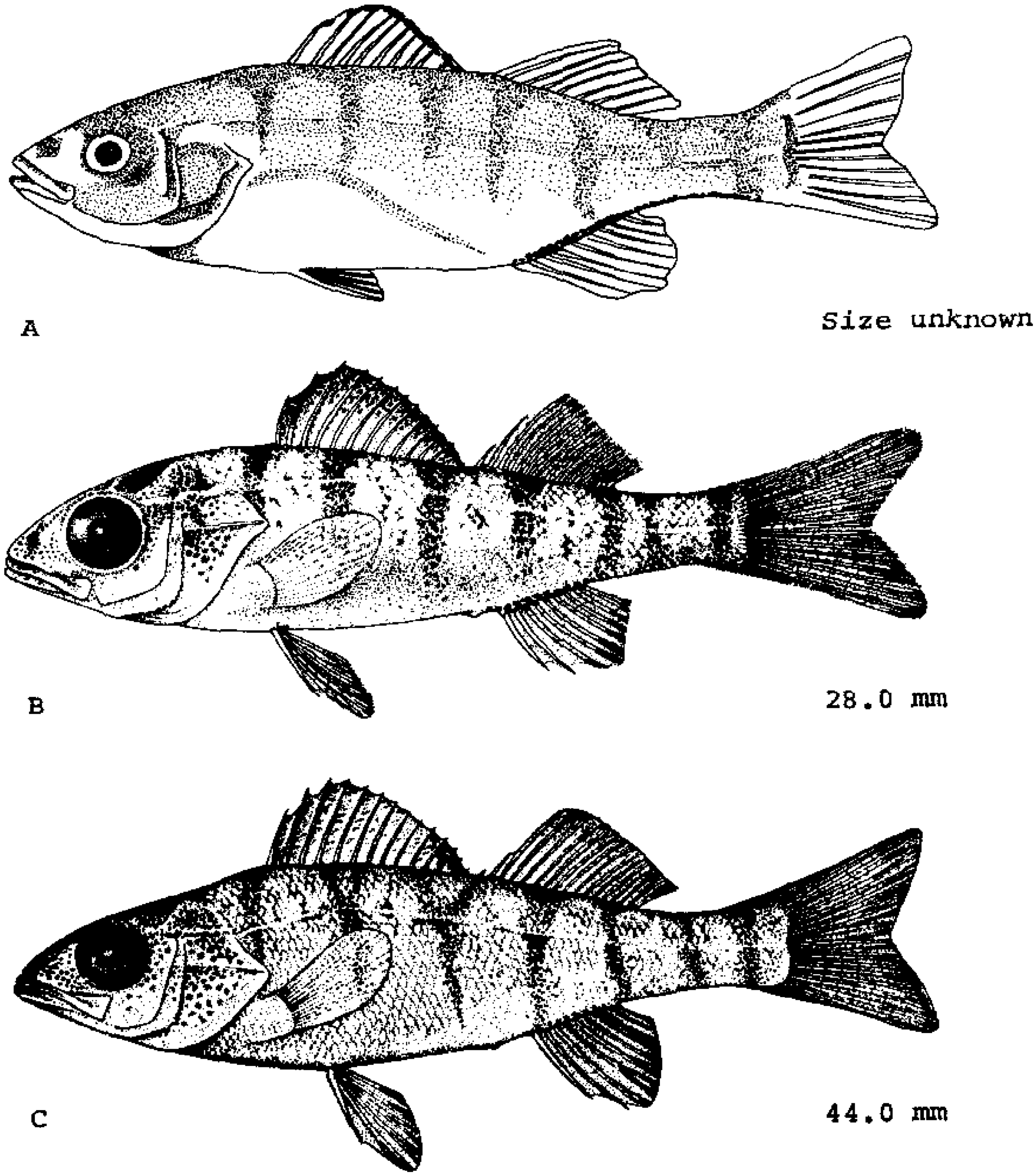
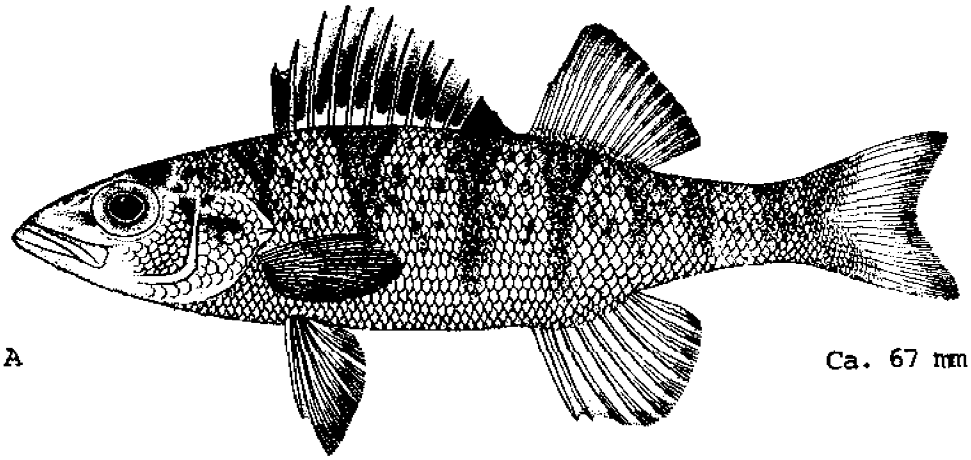


Fig. 192. *Perca flavescens*, Yellow perch. A. Juvenile, size unknown. B. Juvenile, 28.0 mm TL. C. Juvenile, 44.0 mm TL. (*A, Raney, E. C., 1959: 24. B, C, Mansueti, A. J., 1964: fig. 13.*)



A Ca. 67 mm TL

Fig. 193. *Perca flavescens*, Yellow perch. A. Juvenile, ca. 67 mm TL. (*A, Fowler, H. W., 1945: fig. 201.*)

JUVENILES

Minimum size described, 20.0 mm.[55]

Myomeres 17–22 [21] (a preanal count of 24 [55] is questioned, JDH) + 16–21.[21]

In "juveniles" snout-vent length 56% TL.[54]

At 20.5 mm body greatly compressed; [55] "young" more slender than adults; [7] preopercle serrated at 20.0 mm.[21,55] Scalation developed anteriorly along lateral line, and at same time dorsoventrally from lateral line; by 24 mm first fully imbricated scales in region immediately ventral to 12th to 14th lateral line scales; scales fully formed at ca. 36–37 mm, with nape and anterior part of belly last areas to become scaled [65] (in some specimens, however, scales may not be completely formed until length of 49 mm).[54]

Pigmentation: At ca. 20 mm densely pigmented over most of body, lateral body bands and spotting in spinous dorsal evident; [21] in another specimen of this size few chromatophores on head and jaws, on dorsal and anal bases, and on sides from anus posteriorly. In a specimen 20.5 mm long, stellate chromatophores on head and a double row dorsally to end of body; also on sides of head and more or less evenly on sides of body; an indistinct row of large stellate chromatophores ventrally before anus, and an irregular double series ventrally from vent to caudal; dorsal, anal, and caudal speckled. At 22.5 mm lateral banding developed and at 28 mm banding developed and dark, contrasting sharply with ground color; a distinct dark spot over brain; and a pigment concentration along edge of spinous dorsal.[54] All specimens 40 mm long definitely banded.[27,55]

"Young" also described as transparent, silver or dull pale green, [65] with white ground color rather than golden yellow; with bands more prominent than in adults; [63] with indefinite dark spots on sides in addition to black crossbars; [7] and with dark markings at edge and rear of spinous dorsal more sharply defined than in adults.[67]

AGE AND SIZE AT MATURITY

Males mature at age group I,[40] females at age group II+ (third summer).[37] Minimum length at maturity for males ca. 100 mm TL (but in stunted population),[63] smallest female 135 mm FL, otherwise females between ca. 139 and 149 mm TL.[37]

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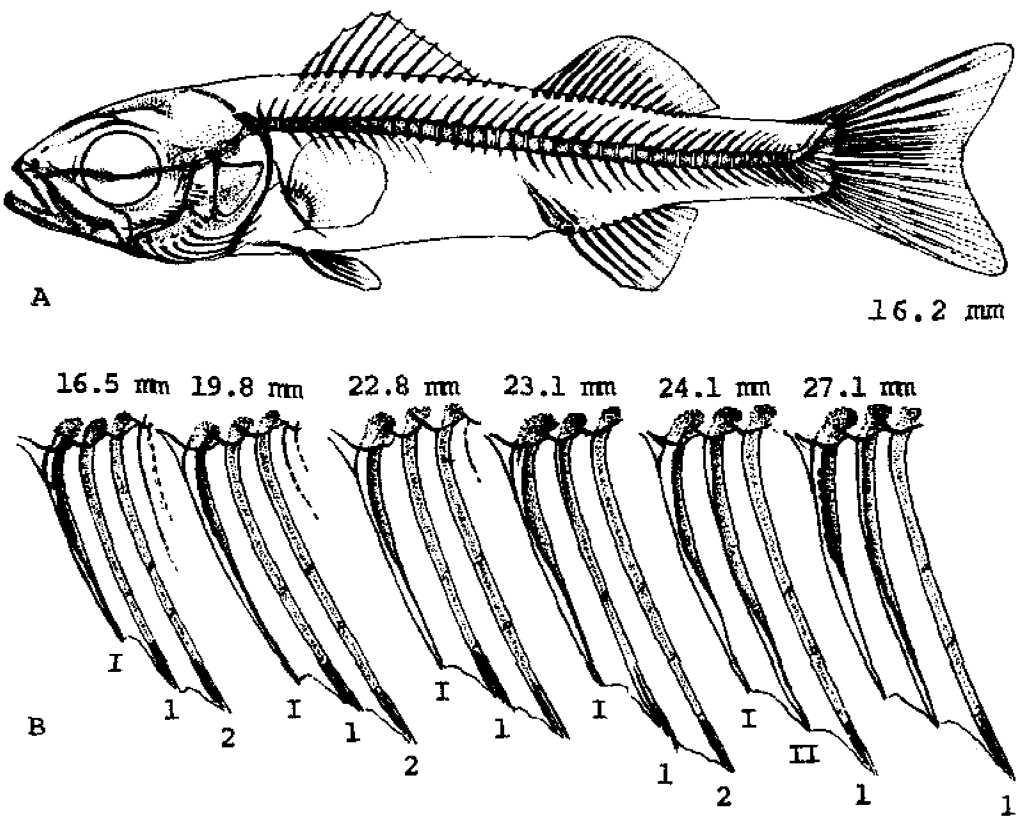

Fig. 194. *Perca flavescens,* Yellow perch. A. Specimen 16.2 mm TL, showing caudal ossification. B. Development of second anal spine from first anal ray through a size range of 16.5–27.1 mm TL. *(A, B, Mansueti, A. J., 1964: figs. 15–16.)*

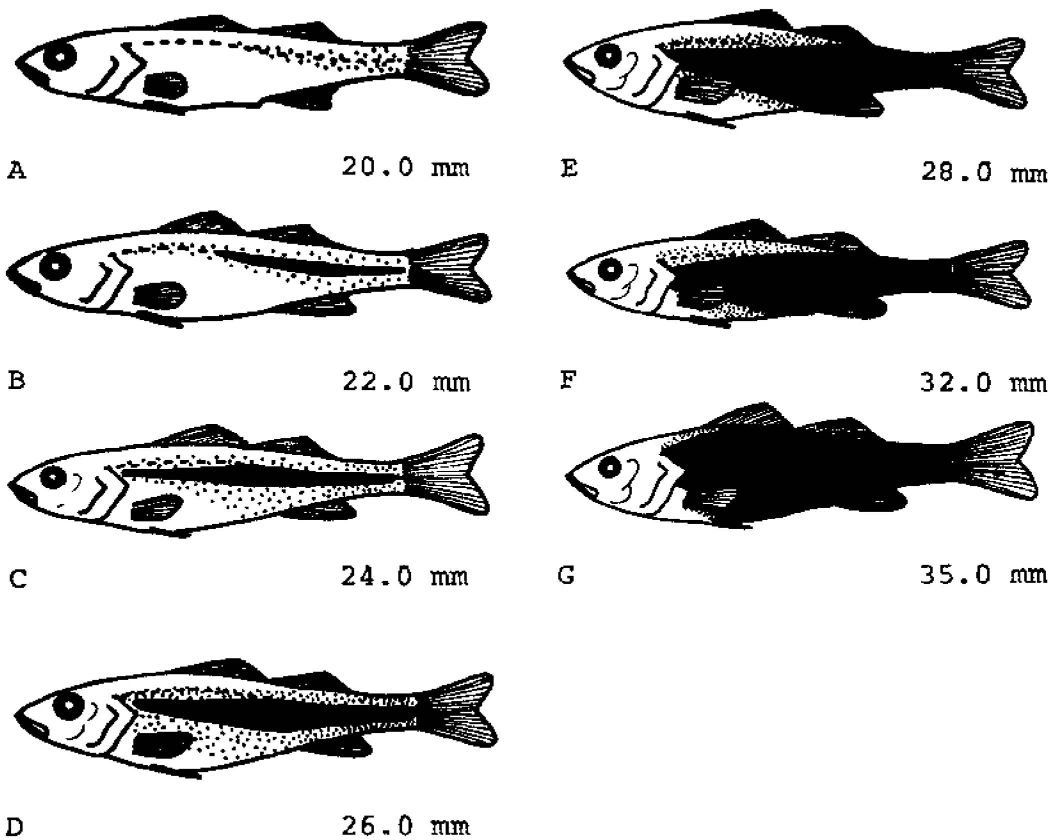

Fig. 195. *Perca flavescens,* Yellow perch. A-G. Development of scales through a size range of 20.0–35.0 mm TL. (*A-G, Pycha, R. L., and L. L. Smith, Jr., 1955: 252–253.*)

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Percina caprodes (Rafinesque), Logperch

ADULTS

D. XII [16] to XVII [19] (reported averages 13.89, 14.27) [35] + 12 [19]–18 [17] (reported averages 13.78, 14.16); [35] A. I to II, 9–12 [17] (reported averages 11.38, 11.62); P. 12–15 (based on total counts of both fins of 25–30), average total counts 27.42–27.83; [35] total lateral line scales 71 [17]–103; [5] pored lateral line scales 76–93; [30] pored scales on caudal fin base 0–5; [9] diagonal scale rows from origin 2nd dorsal to anal base 18–28, diagonal scale rows anal origin to base 1st dorsal 22–32; [7] precaudal vertebrae 23, caudal vertebrae 21; [37] range total vertebrae 40 [17]–46,[1] modal number 42.

Proportions as thousandths of SL: Body depth 156–185, caudal peduncle depth 80–89, caudal peduncle length 217–250, head depth 92–111, upper jaw length 53–66, interorbital width 47–62, longest pectoral ray 161–200, pectoral base 54–68, pelvic fin length 154–182, length of pelvic base 31–48, longest dorsal spine 92–126, longest dorsal ray 109–135.[7] As percent of TL: greatest depth 12.4–17.8. As percent of HL: snout 29.5–36.0; eye 22–28.[17]

Body elongate, tubular, not noticeably compressed laterally except in posterior region; [17] interorbital region broad,[9] concave between eyes; [5] snout conical, fleshy,[7] projected beyond mouth; [16] mouth inferior; [5] premaxil-

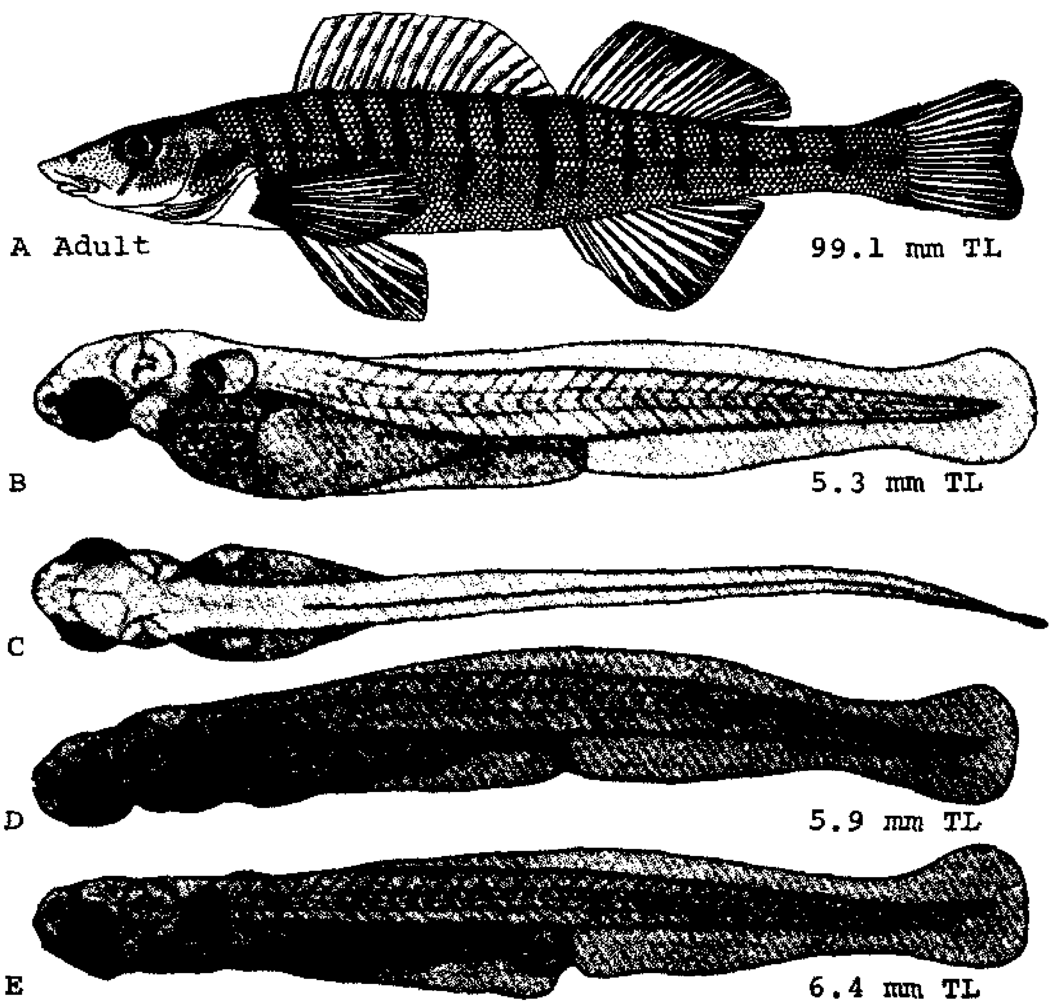

Fig. 196. *Percina caprodes*, Logperch. A. Adult, 99.1 mm TL. B. Yolk-sac larva, 5.3 mm TL. C. Dorsal view of B. D. Yolk-sac larva, 5.9 mm TL. E. Larva, 6.4 mm TL. (*A, Trautman, M. B., 1957: fig. 151. B-E, Taber, C. A., 1969: fig. 17.*)

laries not protractile;[17] gape not extended to front of eye.[19,20] Cheeks and opercle scaled, breast naked; belly usually naked except on females; males usually with rows of scales on midline of belly. Lateral line complete. Dorsal fins separated by one scale row.[17]

Pigmentation: Capable of extreme color changes.[29] Dorsal surfaces dark olive to pale straw yellow[16] and crossed with distinct saddle marks (minimum number reported, 8);[17] or, sometimes, black[33] and with 15[5]–40[29] lateral bars and, usually, with a distinct black caudal spot about as large as pupil.[16] Lateral bars variable: sometimes only to or slightly below lateral line;[5] sometimes only alternate bars below lateral line;[16] in some populations all bars below lateral line;[17] and in some populations bars extended to belly.[20] Ventral surfaces white or tinged with pale yellow.[16] Head with little pigment;[7] a faint oblique tear-drop mark in some individuals;[16,17] cheeks with iridescent green, blue, or yellow; iris with golden margin.[29] Dorsal and caudal fins transparent olive with small, brownish spots which tend to form wavy rows or bands[16] or with splashes of yellow on membranes;[17] a yellow band on first dorsal;[7] lower fins transparent. In breeding males colors more intense.[16]

Maximum length: 180.3 mm[16] (a reported maximum of 254 mm[19] is questioned, JDH).

DISTRIBUTION AND ECOLOGY

Range: Churchill River system, Saskatchewan, to St. Lawrence drainage of eastern Quebec; south through Great Lakes and Mississippi Valley to Rio Grande, Texas, and western Florida.[17,18,24] Introduced in California in 1953.[1,33]

Area distribution: Recorded from New Jersey,[25] and from Potomac River in Chesapeake Bay drainage. Considered endangered in Maryland.[28]

Habitat and movements: Adults—found in streams,[6,19] creeks, rivers,[15,21,26,31] lakes,[13,17,33] reservoirs,[35] ponds, and sloughs in both clear[19] and turbid water[15,29,33] over bottoms of sand,[11] silt,[13] rock, stone,[15,23] gravel,[16,17] and rarely, mud.[15] Sometimes in or near aquatic vegetation such as stonewort or algae.[11,15,16,36] Recorded as abundant in alkaline water in limestone areas.[35] Sometimes hide under rocks or in sand with only eyes protruding;[16] unlike most other darters, swim freely in water column;[31] in winter remain active, even under ice.[21] Maximum depth, 40 m[16] (although apparently prefer water ca. 0.6 m deep).[6]

Migratory. In lakes move to shallow water to spawn, offshore during nonreproductive period; in Michigan arrive inshore between March 22 and May 12[3] (although in other areas may remain in deeper water until first of June, with males arriving in spawning areas before females).[4] In Indiana noted forming "immense schools" (possibly associated with spawning) at mouths of inlets to lakes.[21] In Texas stream populations migrate upstream from deep water to swift rapids in October and November (the reproductive season), migrate downstream and form schools in March and April; in summer form aggregations of 6–10 individuals in deep water of raceways.[5]

Larvae—yolk-sac larvae apparently more restricted to shallow water than larvae; larvae seldom taken at bottom, more abundant in open water;[13] free-swimming for over 30 days.[31] Temperature limits, 14–26 C; best survival limits 22–26 C.[16]

Make diurnal vertical migrations, bottom in daytime, surface at night;[13] carried downstream into Lake Erie soon after hatching.

Juveniles—rarely in surface collections, tend to move into shallow water; no diurnal vertical movements, typically at bottom at all hours.[13] Reported depth, 25.5 mm specimen at 40 m.[32]

SPAWNING

Location: In streams[14] in both quiet and fast moving water, and typically in riffles and raceways; also in lakes and possibly reservoirs.[3,4,35] Spawn at depths of 10.1 cm[15,35] to 2 m[4] over bottoms of sand,[11,12,15] gravel, and boulders.[3,4,35]

Season: In Texas ripe females December 19,[34] spawning January through June[10] (a report of spawning in October and November[7] is questioned, JDH). In Arkansas ripe females April 20 to May 30.[34] In Indiana ripe eggs observed April 6 to April 11,[21] spawning May 30.[15] In Michigan initial spawning varies from early April to mid-June, spawning completed 3rd week of July,[3,8] in New York May 30 to June 25;[27] in Lake Erie continues at least into June;[14] in Canada begins in June.[17]

Time: Early morning to early evening.[4]

Temperature: Initiated at 10–15 C, but ripe females observed at 9–23 C.[34]

Notes on spawning: Spawns in large schools,[3,11] sometimes containing up to several hundred males.[4]

Fecundity: Variously stated: Ca. 100 mature eggs plus large number of immature;[8] also 1060[3] to ca. 3172;[21] in stripping ca. 130–1700 eggs, with distinct geographic variation in egg complement;[2] eggs deposited in each spawning act, 10–20.[3,22]

EGGS

Location: Demersal, deposited in sand or gravel.[3,4,38]

Ripe ovarian eggs: Diameter ca. 1.15 mm, pale in color.[21]

Fertilized eggs: Colorless; transparent;[3] adhesive (thus sometimes coated with sand grains);[17] oil globule single, large, colorless; diameter less than 1.31 mm [3] to more than 1.74 mm; [7] diameter geographically variable, average diameters as follows: in Kerr County, Texas 1.74 mm; in Travis County, Texas 1.63 mm; in Colorado system 1.71 mm; in eastern Guadelupe system 1.60 mm; in Brazos system 1.49 mm; in Illinois River in Arkansas 1.44 mm; in White system in Arkansas 1.59 mm; in Big Mories in Missouri 1.35 mm; [22] in Michigan 1.31 mm.[8]

EGG DEVELOPMENT

Incubation: Will incubate successfully at ca. 11–30 C,[34] incubation period unknown.

YOLK-SAC LARVAE

Hatching length, ca. 4.5 mm; size range described 5.3–4.9 mm.[13]

Myomeres ca. 20+17–18 [13] (derived from drawings, JDH).

Yolk mass and preanal finfold elongate; pectorals rounded at 5.3 mm. Gut apparently short, straight up to 5.9 mm.[13]

Pigmentation: Eye pigmented in smallest specimen described (5.3 mm); 2 or 3 faint pigment spots ventrally between anus and end of tail at 5.9 mm.[13]

LARVAE

Size range described, 6.4–15.0 mm.[13]

Myomeres, in 6.4–15.0 mm series ca. 20–22+17–22 [15] (derived from figures, JDH); at 6.6 mm, 22+16; at 12.15 mm, 20+20; at 14.2 mm, 20+20+.[14]

At 6.6 mm, snout-vent length 4.1 mm; HL 1.1 mm; snout 0.2 mm; eye 0.3 mm; greatest depth before anus 0.83 mm, behind anus 0.87. At 12.15 mm, snout-vent length 6.6 mm; HL 2.06 mm; eye 0.6 mm; greatest depth before anus 1.4 mm, behind anus 0.98 mm. At 14.2 mm, snout-vent length 8.25 mm; HL 3.0 mm; snout 0.67 mm; eye 1.0

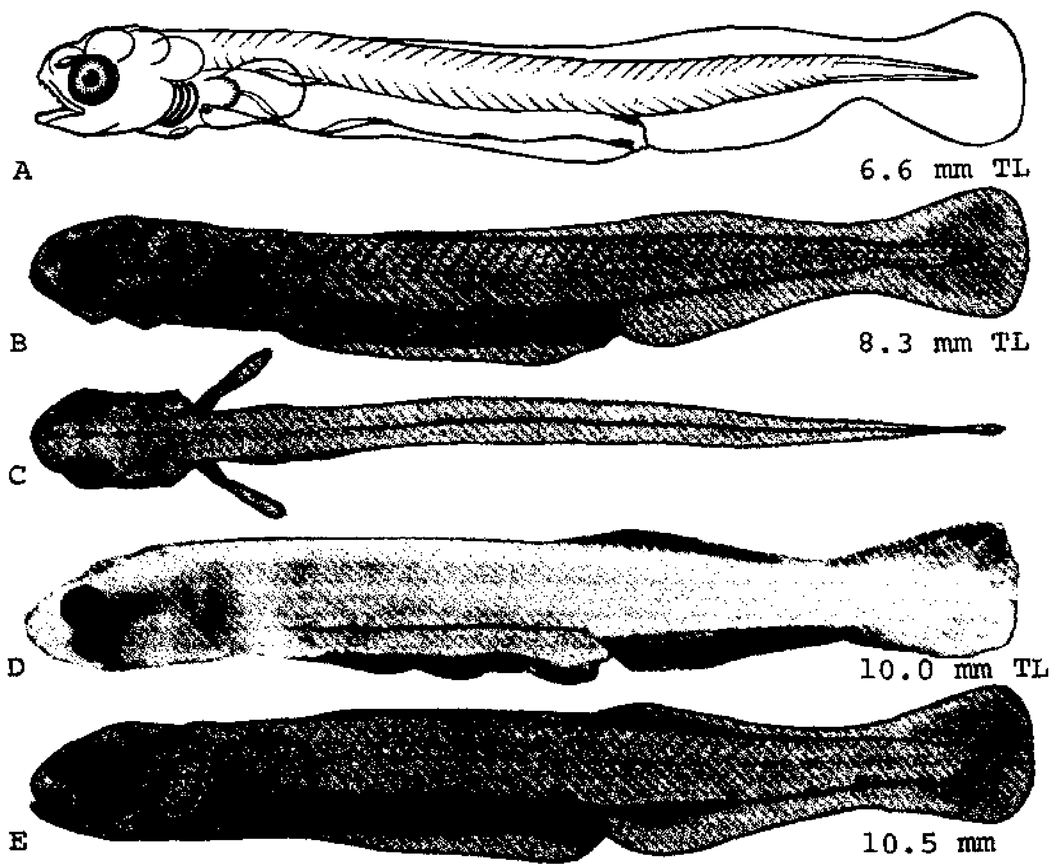

Fig. 197. *Percina caprodes*, Logperch. A. Larva, 6.6 mm TL. B. Larva, 8.3 mm TL. C. Dorsal view of B. D. Larva, 10.0 mm TL. E. Larva, 10.5 mm. (*A, Fish, M. P., 1932: fig. 99. B, C, E, Taber, C. A., 1969: fig. 17. D, May, E. B., and C. R. Gasaway, 1967: fig. 48.*)

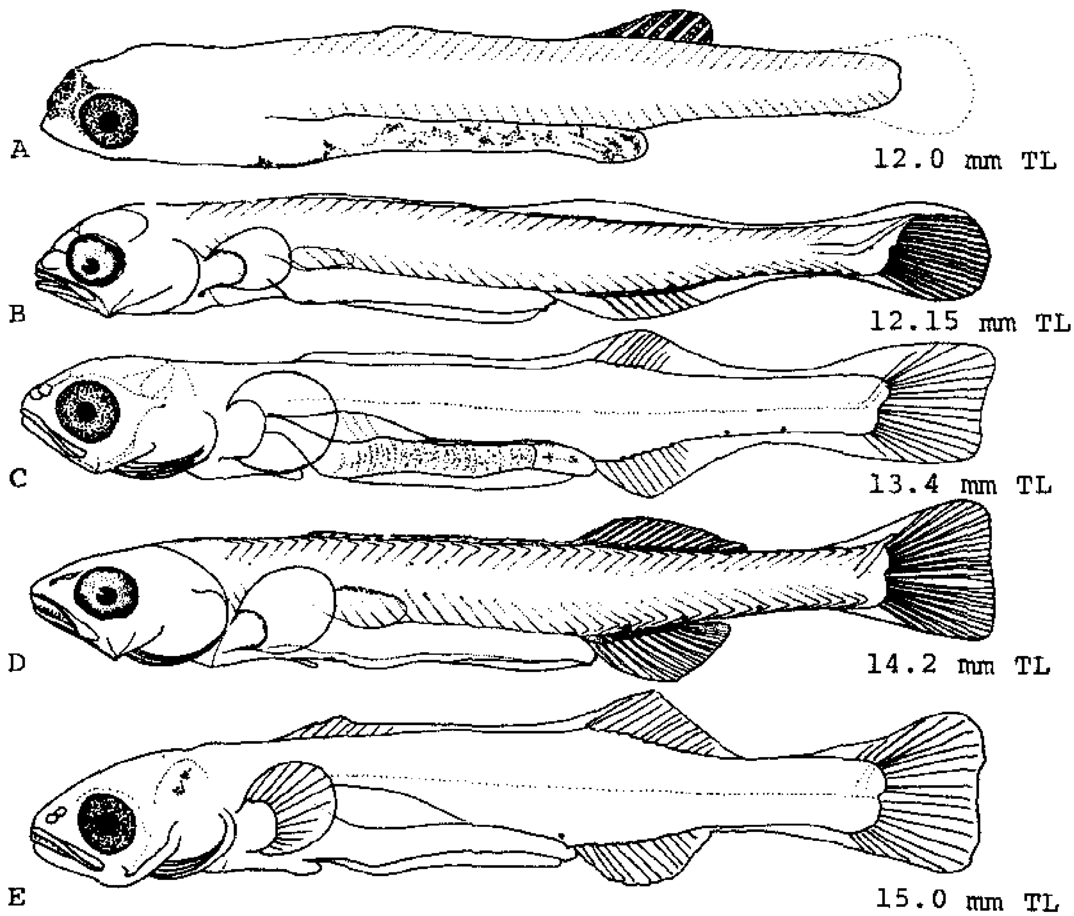

Fig. 198. *Percina caprodes*, Logperch. A. Larva, 12.0 mm TL. B. Larva, 12.15 mm TL. C. Larva, 13.4 mm TL. D. Larva, 14.2 mm TL. E. Larva, 15.0 mm TL. *(A, May, E. B., and C. R. Gasaway, 1967: fig. 47. B, D, Fish, M. P., 1932: figs. 100–101. C, E, Taber, C. A., 1969: fig. 17.)*

mm; greatest depth before anus 2.03 mm, behind anus 1.4 mm.[14]

Body relatively elongate,[13] somewhat compressed; [14] nostrils fully divided at 13.4 mm; mouth large; [13] teeth developed on jaws at 6.6 mm; at 14.2 mm snout definitely pointed, projecting.[14]

At 15.0 mm preanal finfold still evident, and finfold still continuous between anal and caudal. Anlagen of 2nd dorsal and anal fin at 10.5 mm, of 1st dorsal at 15.0 mm; [13] elements of dorsal ray bases evident at 12.15 mm; [14] 2nd dorsal rays developing at 13.4 mm; [13] anal rays first evident at 12.15 mm.[14] Incipient rays in caudal at 8.3 mm; [13] at 14.2 mm caudal fin barely emarginate.[14] Pectoral rays first evident at 15.0 mm.[13] Pelvic buds formed at 14.2 mm. Urostyle oblique at 12.15 mm; [14] gut relatively thick, heavily convoluted at 6.4 mm; [13] gas bladder "rudimentary" at 6.6 mm.[14]

Pigmentation: At 6.4 mm a series of ca. 8 evenly spaced spots ventrally between anus and end of tail, pigment apparently developed on gut.[13] At 6.6 mm a large chromatophore at base of each pectoral, 3 along ventral margin of intestine, one above and one below the anus, and a broken inconspicuous series on ventral ridge to caudal.[14] At 8.3 mm ventrocaudal pigment reduced.[13] At 12.15–14.2 mm pigment developed over gas bladder, body pigment less intense.[14] At 15.0 mm ventrocaudal pigment no longer evident, gut obscured through body wall, but with 2 pigment patches still evident, one at its midpoint, the other above the anus.[13]

JUVENILES

Minimum length described, 20.5 mm.[14]

Myomeres, 22+20+ at 20.5 mm; ca. 20+20 at 25.5 mm.[14]

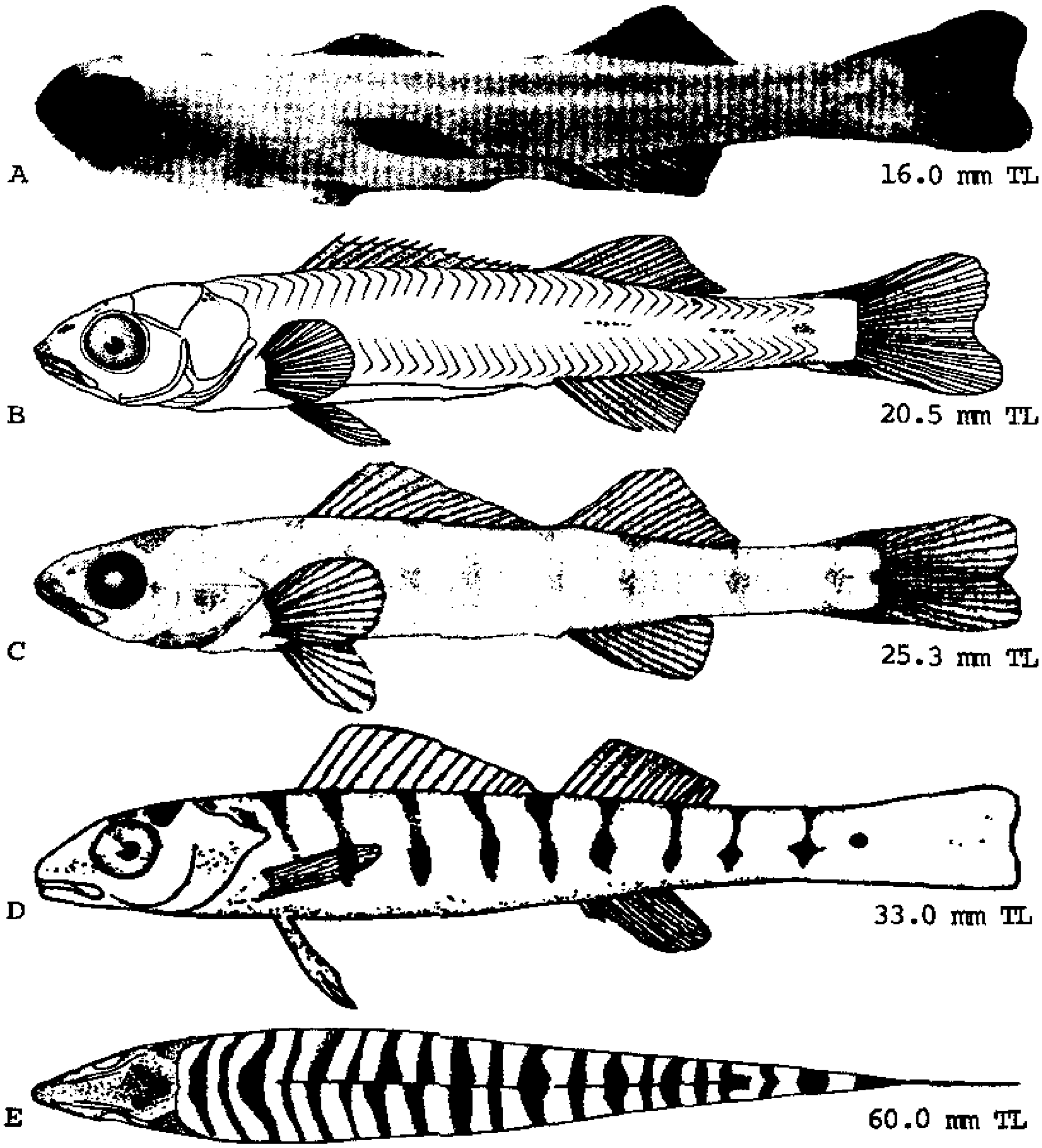

Fig. 199. *Percina caprodes*, Logperch. A. Larva, 16.0 mm TL. B. Juvenile, 20.5 mm TL. C. Juvenile, 25.3 mm TL. D. Juvenile, 33.0 mm TL. E. Juvenile, dorsal view, 60.0 mm TL. (*A, May, E. B., and C. R. Gasaway, 1967: fig. 49. B, Fish, M. P., 1932: fig. 102. C, Taber, C. A., 1969: fig. 17. D, E, Moenkhaus, W. J., 1894: pls. 18–19.*)

At 20.5 mm, snout-vent length 10.8 mm; HL 4.65 mm; snout 1.0 mm; eye 1.35 mm; greatest depth before anus, 3.15 mm, beyond anus 2.53; length to dorsal 6.1 mm, to anal 11.4 mm. At 25.5 mm, snout-vent length 13.5 mm, HL 6.0 mm, greatest depth 4.0 mm, eye 2.0 mm.[14]

Body elongate, slightly compressed; head depressed, rather pointed. Teeth developed on vomer and palatines at 25.5 mm.[14]

Pigmentation: At 20.5 mm tip of snout and both jaws with numerous small chromatophores; chromatophores scattered sparingly over eye and head; 4 short pigment blotches along dorsal ridge, one between dorsal fins, one below middle of 2nd dorsal, one at end of 2nd dorsal, and one approximately at end of body; two pigment blotches along lateral line directly below 1st and 4th dorsal blotches; a double series of chromatophores along ventral ridge from anus to caudal fin, these heaviest around anal base; future caudal spot indicated by several large chromatophores at proximal end of caudal rays; vertical fins dotted with pigment.[14] At 25.3 mm, 6 dorsal blotches and 7 obscure lateral blotches plus one at base of caudal; a prominent pigment blotch on head; pigment developed in distal end of 1st dorsal and in caudal.[18] In a specimen 25.5 mm TL, 8 dorsolateral blotches and ca. 10 lateral bars, chromatophores scattered over jaws, and top and sides of head; a line of small chromatophores from anus to end of body, double around anal fin; dorsal and anal with numerous chromatophores arranged in more or less definite longitudinal barred pattern; caudal dusky with black spot at its base.[14,32] At 30–33 mm 9 crossbars from back to below middle of side, these heaviest at their upper and lower ends. In a 60 mm specimen lateral bars irregular, split.[30] Young of unspecified lengths described as having fewer but more distinct lateral bands than adults and more whitish or silvery coloration.[16,33]

AGE AND SIZE AT MATURITY

Minimum age at maturity, 1 year;[3] minimum total length at maturity, ca. 68 mm (sex not stated);[2] minimum SL at maturity, 54.7 mm (female).[3]

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Percina notogramma (Raney and Hubbs), Stripeback darter

ADULTS

D. XI to XVII,[3] 11–14;[2,4] A. rays 8–10;[3] P. 13–15;[4] lateral line scales 49–67; scales above lateral line 5–9,[3] below 7[2]–12;[5] scales around caudal peduncle 18–24;[3,4] belly scales on males 0–5;[2] vertebrae 40–45.[1]

Proportions as times in SL: Body depth 4.7–5.6, HL 3.2–3.6. Proportions as times in HL: Depth of caudal peduncle 2.9–3.2, highest dorsal spine 2.1–2.9, highest dorsal ray 1.9–2.3, highest anal ray 1.7–2.1, longest caudal ray 1.2–1.7, pectoral fin length 1.0–1.2, pelvic fin length 1.2–1.5, head depth 1.7–2.0, head width 1.7–2.0, eye length 3.7–4.5, snout length 3.8–4.4, upper jaw 3.1–3.6.[4]

Body more oval in cross-section than that of *Percina peltata;*[4] cheek, opercle, and subopercle scaled.[2] Ventral scales of males oval and armed with moderate spines.[2] Pelvic fin base relatively wide;[2] edge of caudal fin nearly straight.[4]

Pigmentation: A series of 7 oval tan blotches dorsally which may or may not[2] be connected to 6 or 8 lateral blotches; lateral blotches connected by lateral stripe; a caudal spot at level of lateral stripe[5] (in preserved specimens this sometimes expanded to form a vertical bar); a light streak across body just in front of dorsal fin; dorsolateral light line connected across body anteriorly;[4] longitudinal nuchal blotch or blotches present[5] and sometimes

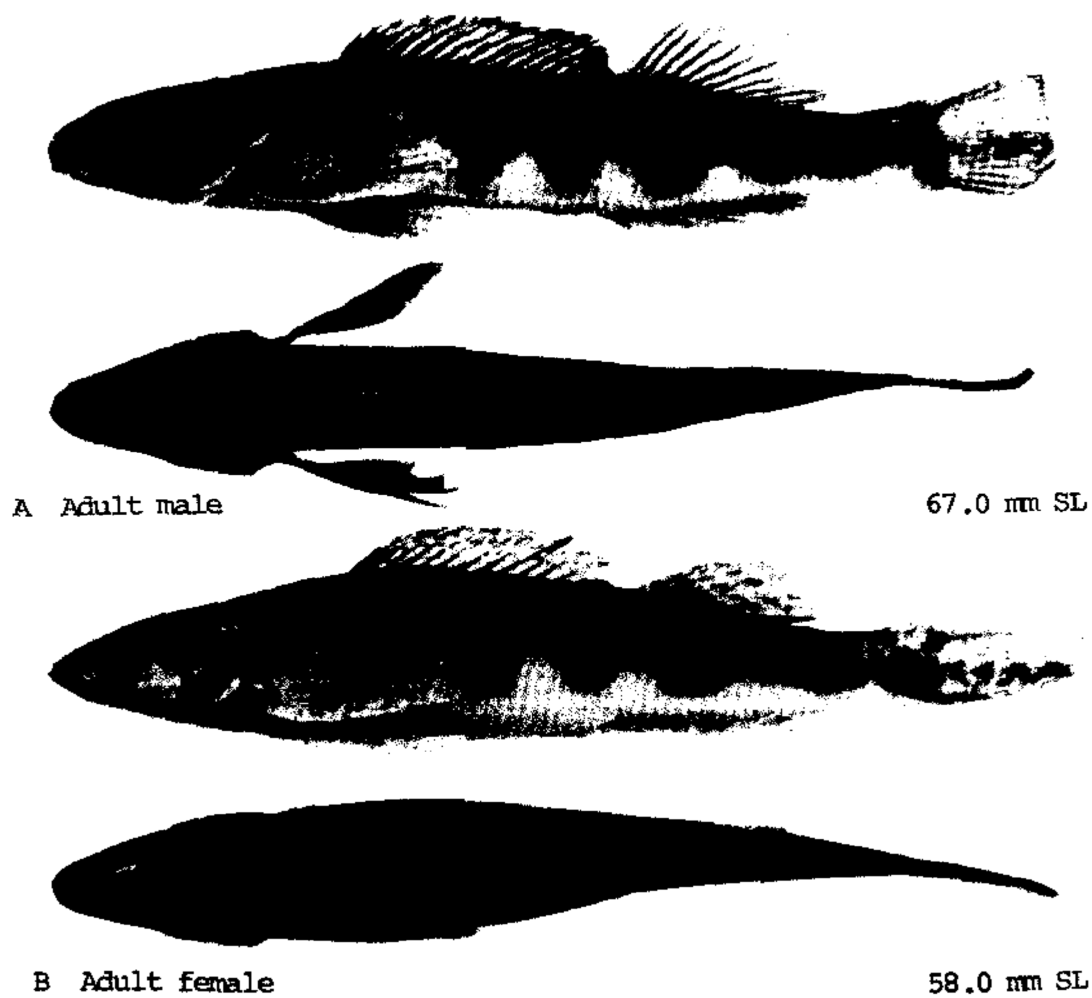

Fig. 200. *Percina notogramma*, Stripeback darter. A. Adult male, lateral and dorsal views, 67.0 mm SL. B. Adult female, lateral and dorsal views, 58.0 mm SL. (*A, B, Raney, E. C., and C. L. Hubbs, 1948: pl. I, figs. 1, 2; pl. II, figs. 1, 2.*)

enclosing a light area;[2] lower sides of head with or without scattered melanophores;[4] subocular bar present.[5] First dorsal fin dark in lower anterior region. Females in life dark with lateral oval blotches blue-black; dorsolateral stripe on body and area around dark lateral blotches golden; other light areas on sides and back and between mandibles amber; mandibles bright metallic blue. Breeding males with black pigment in membrane of first dorsal fin well-developed, caudal fin with 3–4 faint vertical dark bands.[4]

Maximum length: 69 mm SL.[4]

DISTRIBUTION AND ECOLOGY

Range: Patuxent River drainage, Maryland, to James River, Virginia; west to Monroe County, West Virginia.[3]

Area distribution: Tributaries of Chesapeake Bay in Maryland and Virginia; most abundant above Fall Line.[6]

Habitat and movements: Adults—small and medium-size streams (although once taken in Rappahannock River, Virginia); rarely in small brooks;[4] generally in riffle or pool areas over gravel bottom;[3] avoid strictly sand bottom; sometimes in weed beds, particularly in spring. Migrate to spawning areas.[2]

Larvae—no information.

Juveniles—no information.

SPAWNING

Ripe females found at 8–16 C.[2]

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

No information.

AGE AND SIZE AT MATURITY

No information.

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Percina peltata (Stauffer), Shield darter

ADULTS

D. XI to XIV,[2,3] 12; A. II,[8] 8–10; lateral line scales 48–62; [2] scales above lateral line 5–7,[4] below 7–10; scales around caudal peduncle 18–20; belly scales of males 0–5; [2] vertebrae 42–45.[1,4]

Sides of body more nearly vertical than in *Percina notogramma;* [8] head blunt; [2] maxillary extended slightly beyond anterior margin of eye.[8] Cheeks naked or scaly; [6] opercular scales embedded; ventral scales much longer than wide. Pelvic fin base relatively wide; caudal fin emarginate.[7]

Pigmentation: Dorsum pale yellowish with darker saddles; [7] *sides with about 6 quadrate blotches, these* interconnected anteriorly and posteriorly by oblique extensions and enclosing oval light areas; breast with dark, discrete spots; a dark nuchal blotch which encloses a light oval area; a dark stripe behind chin; a distinct crescent mark just below middle of first dorsal fin; a dark stripe behind chin; and a dark caudal spot below middle of caudal fin base.[2,5,6]

Maximum length: 76.2 mm.[7]

DISTRIBUTION AND ECOLOGY

Range: Coastal streams from New York[6] to South Carolina.[7]

Area distribution: All major tributaries of Chesapeake Bay, but mostly above the Fall Line.[9]

Habitat and movements: Adults—in streams and rivers over 3 m wide; usually associated with riffles; uncommonly found over silt, mud, and fine sand; in summer associated with dense growths of aquatic vegetation.[3]

Larvae—no information.

Juveniles—no information.

SPAWNING

Location: In streams in fine gravel which includes a mixture of sedimentary materials ranging from fine to very coarse and rocks ranging from cobble to boulders; depth 305 mm in aquarium, about 1 m in field.[3]

Season: In New York mid-April through May, but may be restricted to two-week period with "whole populations" spent in a period of a few days; ripe males have been observed in every month but August.

Time: Presumably normally during daylight hours[3] (by implication, JDH), but once observed at 2100–2200 hours.[3]

Temperature: 10 C correlated with presence of ripe eggs; actual spawning in field at 11, 12 and 15.5 C; in aquaria 10 C is "threshold" temperature.[3]

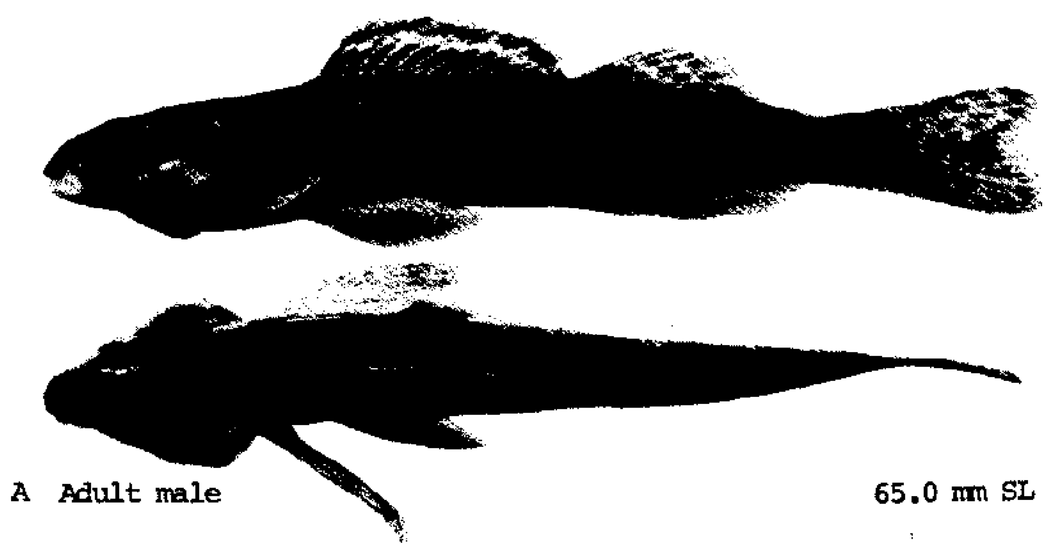

Fig. 201. *Percina peltata*, Shield darter. A. Adult male, 65.0 mm SL. (*A, Raney, E. C., and C. L. Hubbs, 1948: pl. I, fig. 3; pl. II, fig. 3.*)

Fecundity: Based on stripped eggs, 75–125 eggs/female.[3] One female may spawn 12 times in a 2-hour period.[3]

EGGS

Demersal, deposited 6 mm below surface of gravel.[3]

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

No information.

AGE AND SIZE AT MATURITY

Males in age group 0 with milt; no field-collected females this young, but some in laboratory at 40 mm SL.[3]

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Stizostedion vitreum (Mitchill), Walleye

ADULTS

D. XII to XVI (usually XIV)–I, 18–22; A. II, 11–14 (usually 12 or 13); P. 13–16 (usually 14); V. I, 5;[74] lateral line scales 80?–108 (usually 86–92),[74] scales in "lengthwise series," however, given as 110–130; scales in transverse series ca. 35;[5] gill rakers variously stated as 6–8 + 4–5, 7–14 + 6–8, 12–15 + 4–5; branchiostegals 6–8;[74] pyloric caeca 3;[5] vertebrae 44–48.[74]

Proportions as times in SL: Depth 4.1–5.5, head 3.0–3.8.[49] *Proportions as times in HL: Eye* 4.75[18]–6.8.[49] Proportions as percent TL: depth under anterior half of first dorsal fin 12.5–19.3. Proportions as percent HL: interorbital distance (measurements including "young"), 15.7–21.5, *eye* 16.1–26.7, *snout* 25.3–33.5.[74]

Body elongate,[18] rounded[46] or somewhat compressed[18] (the shape varying both geographically and with age);[74] average width typically about 3/4 greatest depth;[46] snout long, bluntly pointed;[74] eye large, prominent;[18] preopercle strongly serrate; opercle with at least one short, sharp spine;[74] mouth large,[18] terminal, almost horizontal; jaws equal; maxillary long;[74] extending to "beyond middle of orbit"[5] or to posterior edge of eye. Teeth on premaxillaries, jaws, head of vomer, and palatines;[74] jaws with some comparatively long canine teeth; jaw teeth otherwise small and in brush-like bands;[46] pharyngeal teeth large, sharp, recurved.[74] Base of first dorsal spine at level with a vertical from base of pelvic spine;[18] lateral line complete, high, slightly curved.[74]

Pigmentation: General ground color described as yellow-

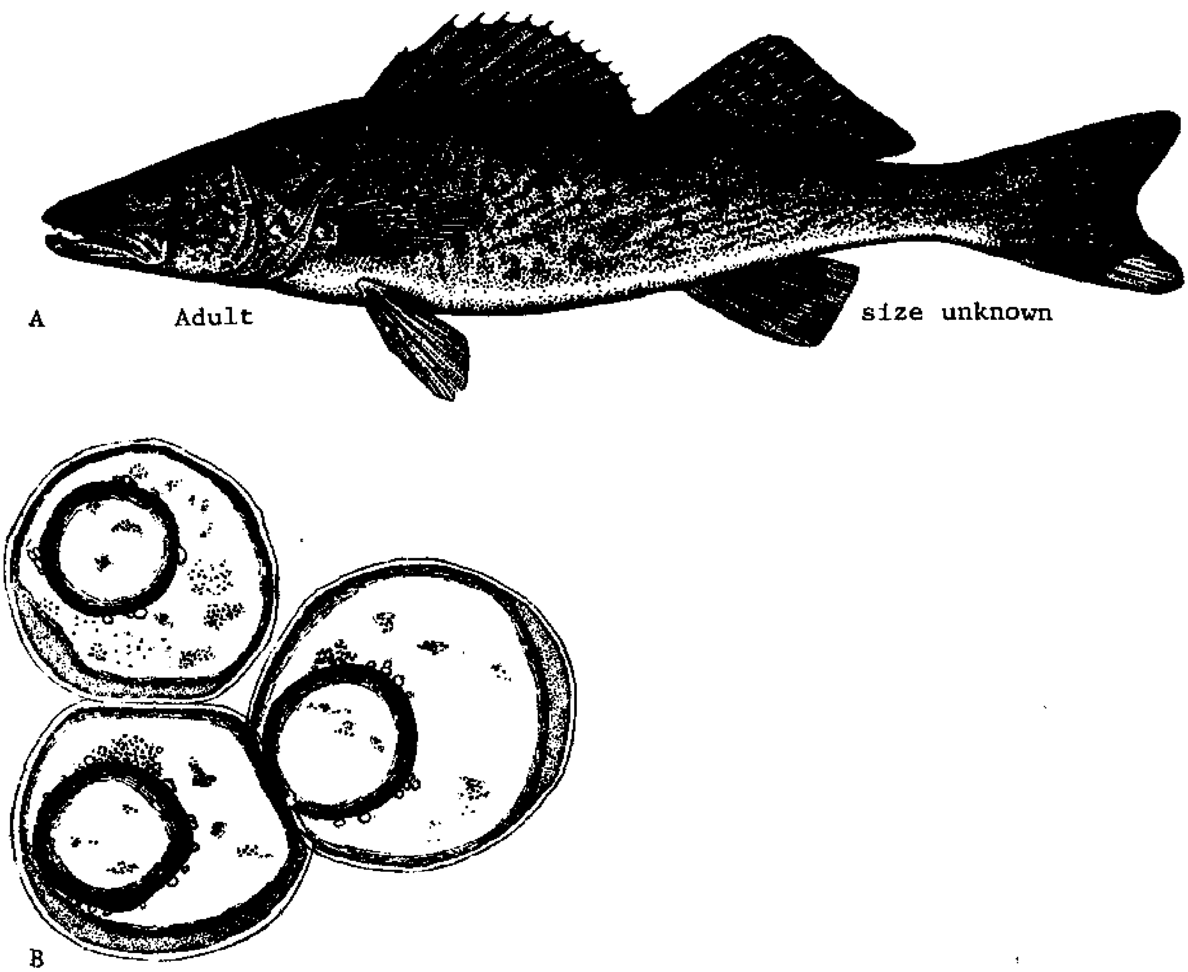


Fig. 202. *Stizostedion vitreum*, Walleye. A. Adult, size unknown. B. Freshly deposited egg, before water-hardening. *(A, Scott, W. B., and E. J. Crossman, 1973: 767. B, Reighard, J. E., 1890: fig. 1.)*

ish,[46] olive golden,[74] greenish brown,[48] brassy,[49] or emerald;[6] also some populations orange, gray-blue, slate-blue, or steel blue. Pigment darkest on head and back;[74] pigment on sides lighter and blending into ventral pigment.[2] Sides vividly marked in clear water, less so in turbid water,[74] with irregular pattern of small dark blotches, particularly above lateral line[2,18] or with brassy or yellowish blotches forming indistinct, oblique lines;[48] scales often with golden flecks.[74] Venter milk white, yellow-white,[74] yellow, greenish,[49] or pinkish.[2] First dorsal with a dark spot on last few rays;[4,74] end of dorsal fin mottled with olive, brown, or yellow[48,67] or with more or less regular rows of tiny dots; tip of anal fin milk white;[74] caudal fin similar to 2nd dorsal, but with tip of lower lobe white;[2] pelvics yellow, orange-yellow, or white; pectorals dark or pale olive with dark blotch at base.[74] Eye described as brown or golden yellow near center, and with milky white cornea.[18,49] Peritoneum white.[74]

Maximum length: Ca. 911 mm.[39]

DISTRIBUTION AND ECOLOGY

Range: From Anticosti Island in the Gulf of St. Lawrence, Quebec, to the southern edge of James Bay, then northwestward to southernmost arm of Great Bear Lake and, occasionally, to mouth of MacKenzie River (northern limit at approximately the 13.9 C mean July isotherm); south from Quebec to New Hampshire and southwest Pennsylvania, then south, west of the Appalachians to Gulf coast in Alabama; northwest to eastern Oklahoma (although possibly through introduction); then to Nebraska and North Dakota and into western Canada; an apparently native stock along Atlantic seaboard from Pennsylvania to North Carolina. Widely introduced elsewhere on eastern seaboard and in most states west of natural range (apparently with varying degrees of success).[2,4,18,34,35,36,46,68,74]

Area distribution: Recorded from various rivers in Chesapeake and Delaware bays drainages.[7,14,46,75] Although specimens have been released in this area (as, for example, into Potomac River in 1901–1904),[14] Scott and Crossman state that the population from Pennsylvania to North Carolina is "apparently native."[96]

Habitat and movements: Adults—a schooling[38] negatively phototropic, crepuscular species[27] usually found in clear, cool water[46,48,65] in lakes[31,45] or moderate to rapidly flowing streams and rivers;[22,30,60] also shallow bayous,[5] and in deep pools in front of riffles;[48] do well in mesotrophic water, less well in oligotrophic and eutrophic environments.[68] Found over bottoms of bedrock,[35] gravel,[6,48] clean hard bottom, rocky reefs,[68] sand, hard clay,[46] and mud;[68] sometimes associated with pondweed[69] or in close proximity to weed beds.[68] Frequently hide under sunken logs, rocks, banks[5,48] or weeds. Maximum depth 27 m.[68] Temperature range 0–32.2 C.[35] Maximum salinity, unknown, but reported to enter brackish water.[15,48]

Make diurnal movements to deep water during daylight hours and inshore to shallow water at night;[54,69] in schools just before sunset, disperse along bottom at night, rise from bottom at daybreak and return to deeper water;[32] thus in Lake Erie at 3–6 m in May and June, at 9–12 m by late August,[68] and in Lake Nipigon at 3–6 m in summer, but at 18–27 m by September.[69] Long distance movements have been recorded but such movements may be exceptional,[8] and the species typically stays in home area except when spawning.[29] In Lake Erie, greatest distance 380 km, but average 40 km;[15] in Michigan 282 km,[58] in St. Lawrence River up to 193 km,[8] in Lake Winnebago 156 km, but average 30 km;[28] in Red Lake, Michigan 96 km (in 68 days), fastest speed 67 km in 33 days.[24] At least some individuals return to same spawning area in successive years;[1,64] but there is evidence to show that such homing is not shown by majority of fishes.[25] Migrate upstream from lakes or rivers to spawn (although some spawn in lakes),[45,49] with older fish moving up further than younger fish;[31] maximum distances definitely associated with spawning 145[28] and 156 km;[31] spawning runs begin shortly after ice is out.[6] Males arrive first on spawning grounds and may stay as long as 3–4 weeks; females enter spawning areas only when ripe and may remain only one day.[31] May stay in headwaters of spawning rivers 3–6 weeks after spawning;[56] thereafter move downstream.[31]

Larvae—phototrophic;[9,23] at hatching swim toward surface, but sink back to bottom immediately; free-swimming by second day;[9,34,59] also described as swimming on back at hatching.[43] After yolk absorption rise to surface.[9] By 10–15 days after hatching dispersed into upper levels of open water,[74] remain pelagic for 4[44,68]–5 weeks.[61] In lakes larvae generally limnetic;[9] typically in open water at or near surface,[45] but also found at bottom.[47] As development proceeds concentrate inshore in coves and bays;[9,36,61,70] sometimes stranded by receding water.[31] Pelagic larvae remain 0.3–3.6 m below surface;[68] typically concentrated in upper 3 m;[9,70] avoid strong current on windy days by descending below 2 m. Yolk-sac larvae drift with bottom current till yolk absorption.[11] In Oneida Lake, New York, move offshore into open water soon after hatching, return to littoral zone as juveniles (30–40 mm); initially dispersed by current, but can regulate their distribution within 1 or 2 weeks after hatching.[9] In Canton Reservoir, Oklahoma, moved from spawning site soon after hatching and assumed nonstratified distribution throughout lake.[36] In Wisconsin move off spawning marshes over 10–15 day period; move downstream in rapid current in upper meter of water; marked larvae thus carried downstream 75.2 km in 43 hours.[31]

Juveniles—strongly phototrophic to ca. 37.5 mm;[68] remain pelagic to 25–30.[31] During summer "fingerlings" may either return to shore areas or remain in open water; [36] when inshore concentrate in bays or in sheltered areas [31] along shore,[36] sometimes forming loose schools; [31,45] usually near well-developed beds of rooted aquatic vegetation.[54,68] Typically over bottoms of sand, gravel, silt, rubble, or boulders.[54,69] Recorded depth range, "a few inches" to 12 m.[31] Optimum temperature, 22 C. Upper lethal temperature (when acclimated at 8–26 C for 96 hours), 27.0–31.6 C.[73]

As summer progresses young-of-the-year generally move into deeper water [54,71] and become demersal; [9,36] in early July in water up to 0.6 m deep; in early August in and about weed beds in water ca. 1.2 m deep; by August rarely in water less than 1.5 m; by early to mid-September in water 3–3.6 m deep, and in definite schools.[54] Some populations as deep as 12 m by October.[68] In Oklahoma concentrated near bottom in deeper water from November through February.[36] Apparently not all individuals follow this pattern. Some young-of-the-year may undergo rather extensive movements in winter, remaining active under ice.[68]

SPAWNING

Location: Streams,[17,21] creeks,[31] rivers,[20,45] lakes,[21] bayous,[31] and marshes.[28] Moving water of at least moderate current is a common requirement of all spawning sites; [36,69] in rivers, streams, etc., on riffles; [31,55] in swift flowing water below rapids; [71] below waterfalls [49] and dams; [71,74] also in main channels and along banks where grassy vegetation occurs; rarely in flooded areas over bottom of soft muck-detritus, but in such areas egg mortality is high; [31] in lakes along shoreline [31,69] on gravel shoals and bars,[5,6,31] also where rock-bottomed clear rivers enter lakes; [2] typically where wave action keeps water in motion [36] or in areas where waves break over rocks. In some areas spawning in lakes may occur only if adults are "prevented by weather from entering streams." [69] Spawning in marshes is limited to those marshes having both inlets and outlets and, consequently, good water flow; in Spoehrs Marsh, Wisconsin, spawn as far in marsh as possible during periods of high water level, in deeper channels at times of low water.[31] Typically on gravel bottoms; [17,21,36,39,42,48,68,71] also over rocks,[21,39,42,68] boulders,[17,65] rubble,[36,65,68] root masses,[31,39] and vegetation; [28,68,71] rarely over sand,[36,48,71] sand and muck, and muck-detritus (in sandy area generally spawn on isolated patches of gravel [17] and have been observed to fan away 5–25 cm of sand to locate gravel and broken rock).[42]

Depth 5 cm to 3 m.[2,17,65,69] Minimum distance from shore, 3 m.[71]

Season: In Oklahoma, concentrate at spawning sites in March, peak of ripeness in mid-March, few ripe fish in May; [36] in North Carolina in "early spring"; [5] in Pennsylvania ends in June; [6] in New York spawning run begins in March,[36,54] major activity apparently in April,[69] spawning complete in May; [6] in Michigan mainly in April and May,[43,65] in one 15 year study average beginning April 4, average end April 22, average peak April 12–14; [71] in Minnesota April 5 (beginning of run) [57] to May 16; [17] in Wisconsin April 2 to May 4,[31,36,39] peak April 13 to April 17,[28,71] season also described as beginning 4–20 days after break-up of ice; [31] in Ontario, March and April; [20,74] in Saskatchewan April 8 to May 31, peak April 30 to May 21; [36,38] in "far north" end of June.[74] Spawning typically begins after break-up of ice; [31] but in years in which ice leaves late, spawning adults may congregate under ice,[71] and in Lac La Ronge, Saskatchewan, spawning has been observed under ice.[38]

Time: Mostly at night, but also between 1330 and 1600 hours, and sometimes in bright sunlight; [2,69,71] captive fish spawned between 1700 and 1900 hours while wild fish spawned later.[3]

Duration: 5 [38]–28 days,[57] with shortest period reported in Saskatchewan (5–7 days).[38]

Temperature: Overall spawning activity (spawning run, prespawning behavior, and spawning) at 1.1–17.2 C.[31,35,36,39,42,46,55,69,71,74] Peak activity variously described at different temperature ranges (apparently varying geographically): 5.6–7.8 C, 7.2–10.0 C,[36] 7.8–8.9 C,[71] and 8.9–10.0 C.[39] Optimum temperature for fertilization of eggs 6–12 C.[73] Extreme northern populations do not spawn in some years when temperature is not favorable.[74]

Fecundity: 23,000–615,166; [2,6,19,26,31,66,74] average total eggs, 50,000–60,000,[69] 90,000,[19,46] and 113,404,[31] average number free-flowing eggs, 49,614; [55] estimated average eggs per kg of fish, 28,474–ca. 99,200.[5,19,26,55,65,69] Egg production at various body weights: at 2–2.2 kg, 118,000; [45] at 2.2 kg, ca. 100,000; [52] at 5.4 kg, 388,000.[55] Egg production at various body lengths: at 343.0–556.0 mm, 35,000–137,000; at 636.0 mm, 87,400; at 654.0 mm, 77,500, at 673.0 mm, 87,000; [19] at 698.5 mm, 238,110; [26] at 838.2 mm, 171,300.[19]

EGGS

Location: Broadcast at random; [31] semibuoyant [5,46] or demersal,[13] with specific gravity described as "slightly greater than water" [31] to "high." [13] Typically deposited in running water [49,51] over boulders,[17] gravel, rubble,[2] gravel-rubble [31] (where survival is best), sand,[17] muck and detritus,[31] soft muck (where survival is lowest),[17] submerged sticks,[49] and mats of grasses and sedges.[31] Initially adhesive,[2] but ultimately fall in crevices in substrate.[68,74] Under laboratory conditions tend to adhere together in masses,[5] but a report of eggs in "ribbon-like masses" [68] is doubted (JDH). Definitely observed in water 5 [31]–122 cm deep,[39] but presumably deeper if spawn-

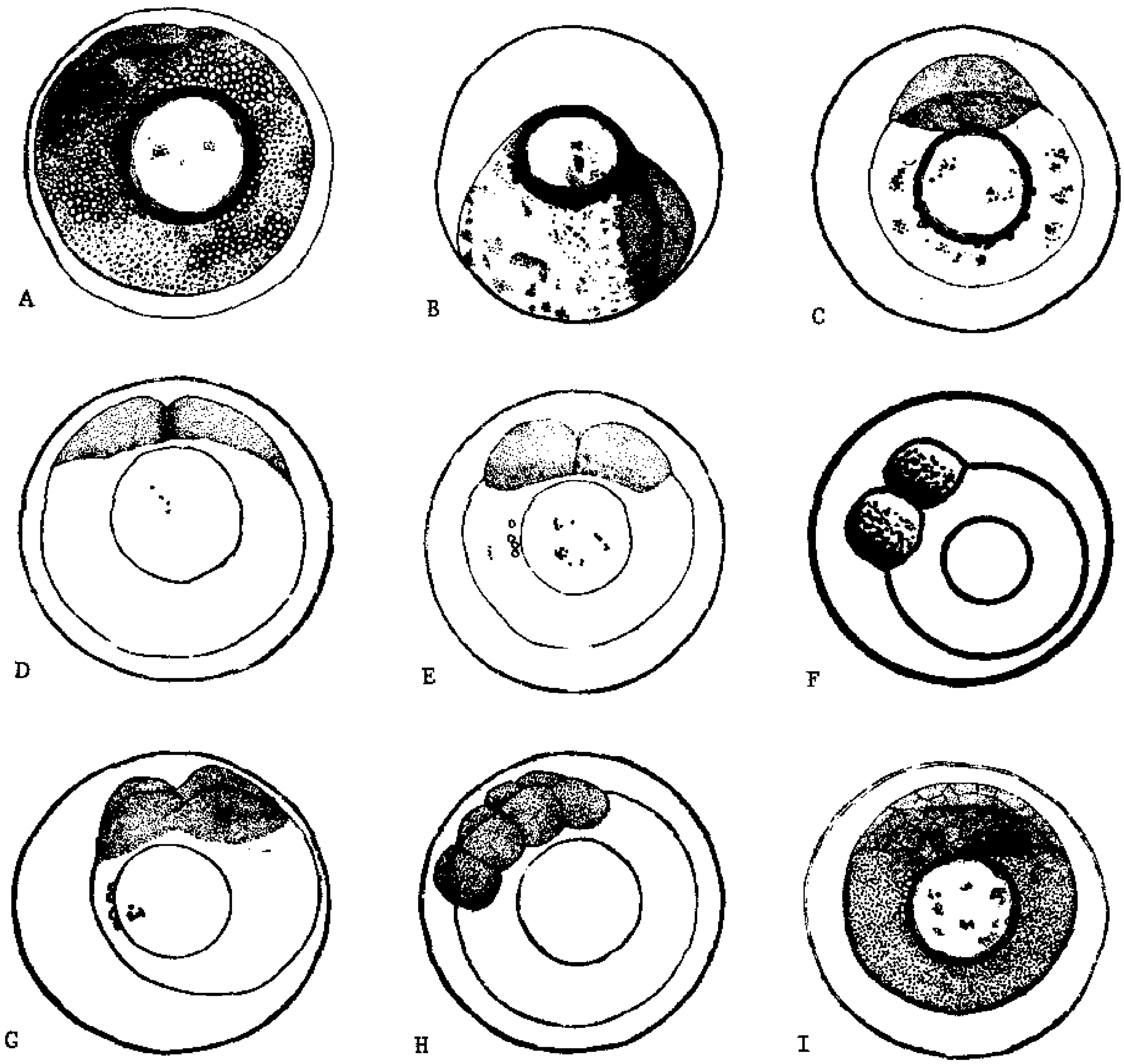


Fig. 203. ***Stizostedion vitreum***, Walleye. A. Egg shortly after deposition and partially water-hardened. B. Egg fully water-hardened, age unknown, blastodisc formed. C. A similar egg, rotated upward. D. 2-cell stage, 4 hours old. E. 2-cell stage, the cells noticeably peaked, 4 1/2 hours after fertilization. F. 2-cell stage showing maximum development of first cleavage blastomeres. G. 4-cell stage, 4 hours and fifty minutes. H. 8-cell stage, 6 hours. I. Late cleavage stage, 27 hours. (*A-E, G-I, Reighard, J. E., 1890: pls. 1–2. F, Olson, D. E., 1966: fig. 2.*)

ing takes place at 3 m [69] (JDH). Sometimes in windrows after storms, and sometimes stranded by receding water; dead eggs observed in clumps of filamentous algae.[17] Can move with current for considerable distances; consequently, sometimes washed to detritus substrate in deep holes where mortality is high.[81]

Mature ovarian eggs: Ca. 1.0 mm in diameter.[63]

Ripe eggs: *Diameter 1.40–2.04, average 1.72 mm.*[26]

Unwater-hardened eggs, presumably unfertilized: 1.3 [43]–1.85 mm, average 1.73.[13]

Fertilized eggs: Spherical; [13] "light-colored," semitransparent; [66] diameter 1.49–2.03,[5,6,41,43,45,40] or 2.31 mm [40] averages stated as 1.66,[16] and 2.07; [40] chorion hyaline, initially turgid, often flaccid just before hatching; [17] adhesive when first ovulated,[2,8,37,46,50] nonadhesive after water-hardening [13,31] *or at age of one hour.*[39] Yolk diameter

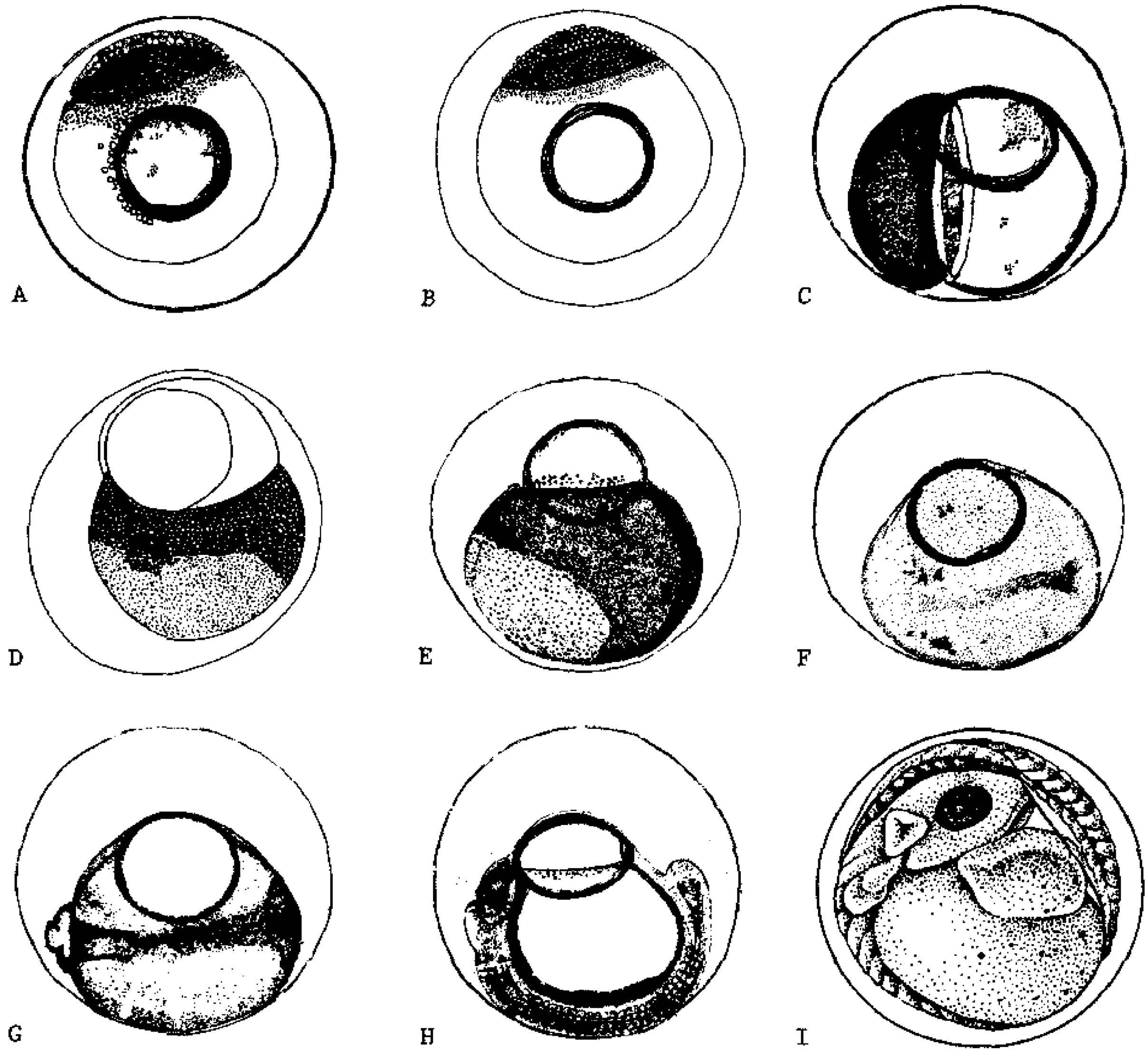


Fig. 204. *Stizostedion vitreum*, Walleye. A. Morula, 30 hours. B. Morula, 37 hours. C. Early embryo, 56 hours. D. Embryo over two-thirds of yolk, 70 hours. E. More advanced embryo, 72 hours. F. 78 hours, dorsal view of developing embryo. G. 100 hours, somites forming. H. 148 hours, eye well formed, auditory vesicle evident, tail almost free. I. Advanced embryo showing characteristic pigmentation. (*A-H, Reighard, J. E., 1890: pls. 3–5. I, Nelson, W. R., 1968: fig. 1.*)

1.02–1.43 mm, average 1.28 mm. Oil globule single, diameter 0.60–0.77 mm, average 0.67 mm.[13]

EGG DEVELOPMENT

Development at temperatures of ca. 7.2 to ca. 10.3 C: [46]

2 hours (estimated, JDH)	eggs fully water-hardened; germinal disc contracted, forming lens-like projected mass.
4 hours	2-cell stage.
4 hours, 30 minutes	2-cell stage, the blastomeres more elevated than in previous stage.
4 hours, 50 minutes	4-cell stage (estimated from drawing, JDH).
6 hours	8-cell stage, blastomeres usually arranged in two rows of 4 each.
27 hours	late segmentation.
30 hours	morula.
37 hours	late morula.
56 hours	blastoderm over more than 1/3 yolk, edge of blastoderm opaque.

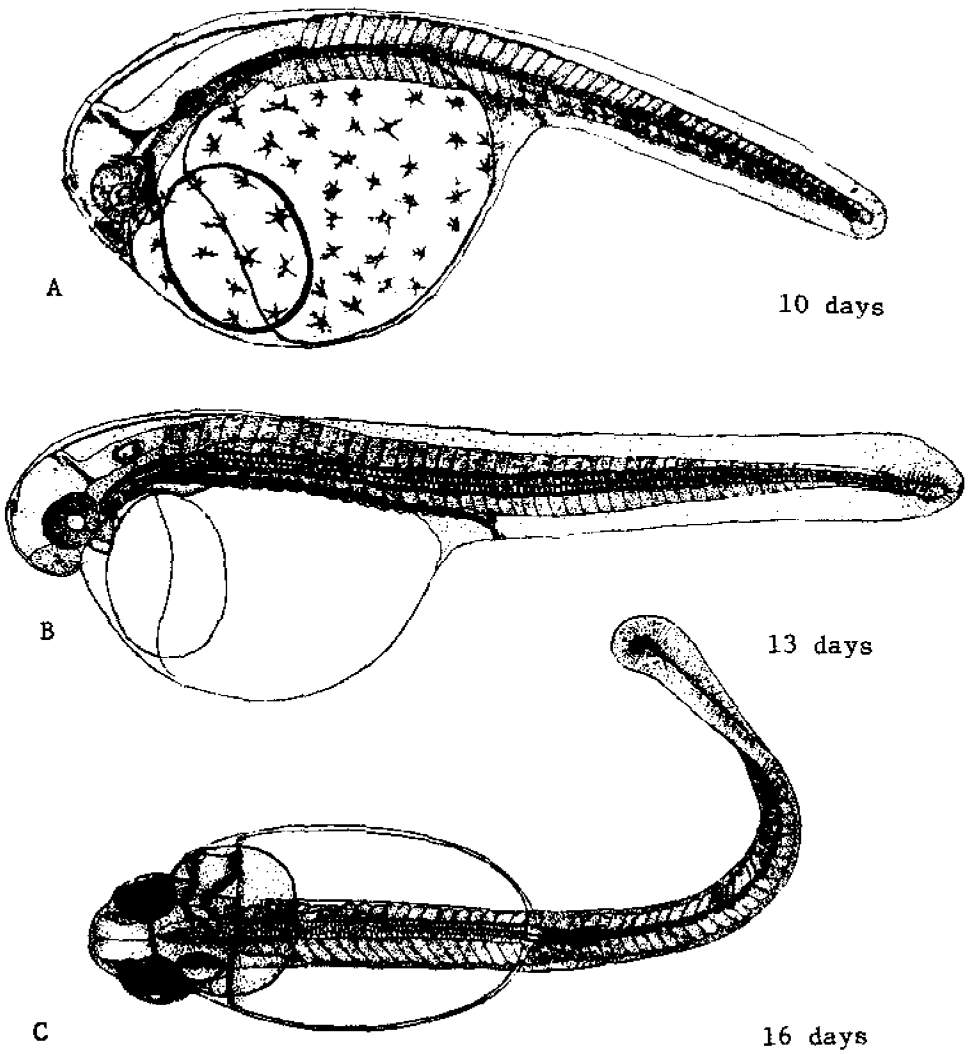


Fig. 205. *Stizostedion vitreum*, Walleye. A. Embryo at end of tenth day, chorion removed. Note pigment on body and yolk. *B. Embryo at end of thirteenth day, pigment omitted. C.* Embryo at end of sixteenth day, ventral view, pigment omitted. *(A-C, Reighard, J. E., 1890: pls. 6–7.)*

70 hours	blastoderm over ca. 1/2 yolk, yolk noticeably constricted.
72 hours	blastoderm extended to oil globule, embryo distinct.
Ca. 100 hours	embryo ca. 1/2 distance around yolk; notochord well defined; somites, eyes evident.
End of 5th day	10–12 somites formed, blastopore closed.
6 days, 4 hours	embryo around 2/3 yolk, head deflected over oil globule, tail rounded, auditory vesicle formed.
8th day	embryonic movement.
End of 10th day	otoliths, proctodeum formed; tail free (although probably initially free prior to this stage, JDH) and flattened; pigment on yolk and lower half and side of tail.
End of 13th day	alimentary canal essentially a straight tube, not open anteriorly or posteriorly; notochord distinctly granular; gill slits formed; incipient rays reported in caudal fin (although this is unlikely, EDH); eyes becoming pigmented.
End of 16th day	anlagen of rays in "median fins" (although this report probably in error, EDH).

24 1/2 days	hatching.[46]

Notes on development: At 7.2–10.0 C, first cleavage at 5–6 hours; embryo formed at 4 days; pigment evident, heartbeat established, red blood cells developed at 6 days.[46] At ca. 10.0 C under various O_2 levels, at 6 days eyes formed, not pigmented; heart beating; tail free; chromatophores on yolk sac.[59]

At unspecified temperature waterhardening may be delayed for up to ca. 5 hours.[37] Also at unspecified temperature, first cleavage began at 6 hours, completed in all eggs at 7 hours and 40 minutes. In a separate experiment first cleavage occurred between 1 and 19 or more hours after fertilization.[76] In a sequence in which hatching occurred on the 7th through 9th days, embryo formed on the 3rd day, tail free on 4th day, pigment in eye on 5th day.[34] Embryos just before hatching have distinct well-developed eyes and numerous chromatophores on yolk sac and along ventral line from anus to caudal peduncle.[40] In advanced embryos ca. 45 somites.[13]

Development at various temperatures and temperature ranges:

At 3.9–12.2 C (388 thermal units)	28 days.[77]
At 4.4 C	26 days.[39]
At ca. 4.4 C	28 days.[46]
At 5.6–13.9 C (398–467 thermal units)	25–27 days.[78]
At 6.1 C	30–49 days, median 34 days.[73]
At 6.7–12.2 C (388 thermal units)	22 days.[77]
At 6.7–12.8 C (462–478 thermal units)	28–29 days.[78]
At 7.2 C	14–30 days[6] "or a little less than 3 weeks."[5]
At ca. 7.2–10.3 C	25 days.[43]
At ca. 8.9 C	18–20 days,[46] 23–31 days, median 27 days.[73]
At 9.5 C	21–25 days.[34]
At 10.0–12.8 C	21 days.[39]
At 12.0 C	12–18 days, median 15 days.[73]
At 12.8 C	14–18 days.[40]
At 13.9 C	7 days.[45]
At 15 C	8–11 days, median 10 days.[73]
At 18.1 C	6–8 days, median 7 days.[73]
At 20.9 C	5–6 days, median 5 days.[73]

Development at various mean temperatures:

At 8.3 C (range 5.0–16.1 C)	20–24 days.[17]
At 9.4 C (range 6.1–12.8 C)	16–21 days.[17]
At 10.0 C (range 6.1–12.8 C)	16–21 days.[17]
At 10.6 C (range 7.2–15.6 C)	12–18 days.[17]
At 10.6 C (range 7.2–17.2 C)	16–18 days.[17]
At 11.1 C (range 6.1–13.3 C)	14–16 days.[17]
At 11.7 C (range 7.8–14.4 C)	12–14 days.[17]
At 11.7 C (range 8.9–14.4 C)	12–14 days.[17]
At 13.9 C	7 days.[39,43]

Koenst and Smith have commented on two possible "optimum" temperature ranges: 9–15 C, 16.7–19.4 C.[75] Various populations appear to have different upper temperature tolerances. Specimens from Texas (introduced from Iowa) develop at 20 C; specimens from Ontario "have trouble" at 16.5 C.[34]

Incubation period as related to oxygen level: At low O_2 levels mean incubation time is extended and mean hatching length is less;[10] at ca. 10.0 C, 11 days at highest experimental O_2 levels (ca. 10 ppm), 16 days at lowest O_2 level (0.8–1.3 ppm).[59] Nineteen days at 7 ppm O_2 concentration (12.4 C), 22 days at 3 ppm (temperature not stated); at 12.1 C, 22–23 days at 6 and 3 ppm O_2 concentration; at 13.2 C, 15–18 days at 4 and 2 ppm O_2 concentration; 29–33 days at 6 and 3 ppm O_2 concentration when exposed to 4.0–5.0 C for 21 days and 12.3 C for remainder of experiment.[10]

Temperature as possibly related to hatching success: Eggs incubated at 7.5, 8.3, 8.9 and 9.7 C yielded hatch successes which varied from 47 to 56 percent; in temperatures of 6.1, 9.4 and 10.0 C, hatching success varied from 20 percent (at 6.1 C) to 80 percent; 12.2 C yielded a hatching success of 30 percent. In this experiment it was pointed out that temperatures below 4.4 C might be injurious to eggs.[56]

YOLK-SAC LARVAE

Hatching length 4.8–8.7 mm[13,31,40,41,59,61,69,70,74] (a report of hatching at 12.7 mm[39] probably in error, EDH). Mean hatching lengths variously reported: 6.0–7.8 mm,[73] 7.0–7.5 mm,[9] 7.6 mm,[31] and ca. 8.0 mm.[13] Mean hatching lengths varied from 6.3–7.6 mm under different O_2 concentrations.[15] *Length at end of stage,* 9.0–9.6.[33,40,61,70,72] Feeding begins at age of 7–8 days[37] (before total loss of yolk[74]). Duration of stage, 9–10 days at 11.7–16.1 C;[78] otherwise, at unspecified temperature, *yolk gone by 38th day after fertilization,* oil globule by 44th day.[43] Myomeres 16[39]–22 + 20[40]–29;[74] average preanal myomeres, 19.7; average postanal myomeres, 25.8.[40]

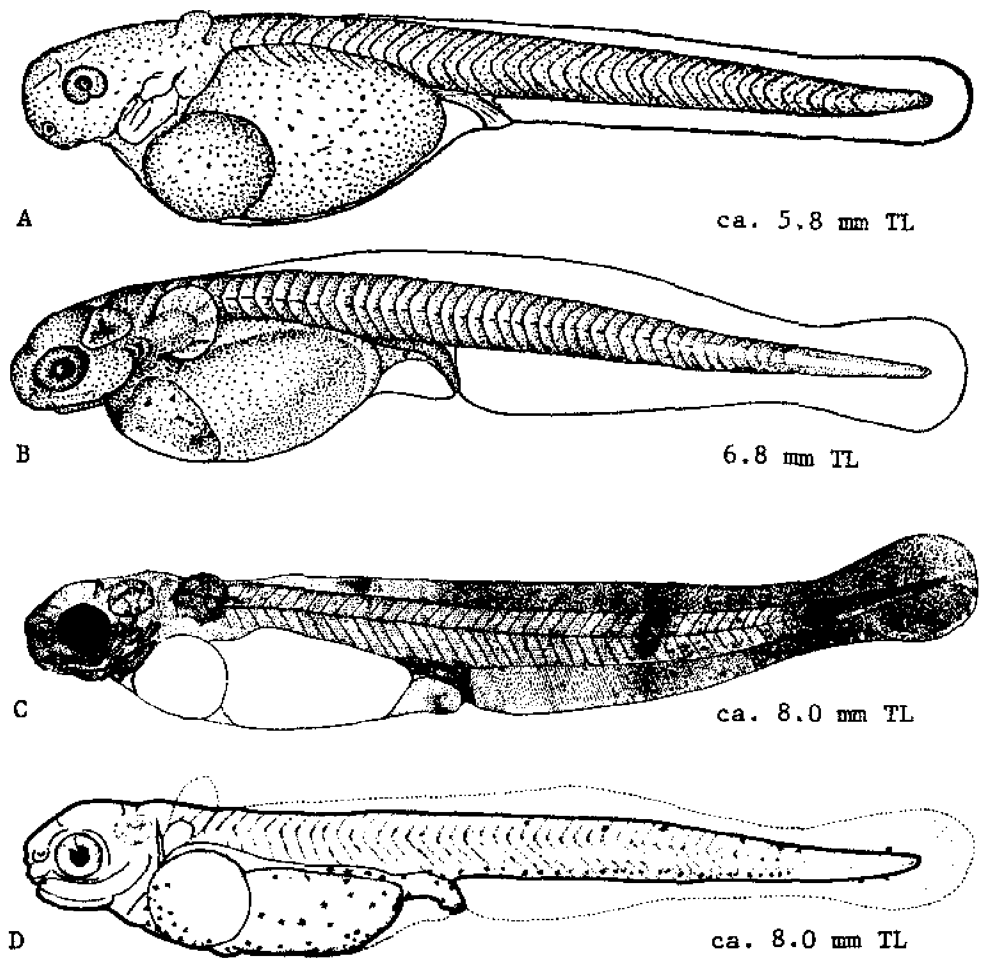


Fig. 206. *Stizostedion vitreum*, Walleye. A. Yolk-sac larva, ca. 5.8 mm TL. B. Yolk-sac larva, 6.8 mm TL. C. Yolk-sac larva, ca. 8.0 mm TL. D. Yolk-sac larva, ca. 8.0 mm TL. (*A, Ryder, J. A., 1887: fig. 45. B, Nelson, W. R., 1968: fig. 2. C, Reighard, J. E., 1890: pl. 8. D, Norden, C. R., 1961: fig. 4.*)

In hatchlings 6.13–6.88 mm long, yolk sac 2.13–2.88× 0.83–1.25 mm; [40] anus to caudal distance ca. 10% greater than snout to anus distance.[33] At hatching, body elongate; [18] head extended forward beyond yolk sac; [43] oil globule in anterior part of yolk sac, round, clear; [33] mouth open but only partly developed (EDH); choroid fissure closed. Origin of dorsal finfold at 2nd [40] to 6th myomere, and with slight rise posterior to vent; [33] preanal finfold present.[40] Pectoral buds developed at hatching.[40,41,43] Gas bladder evident at 9.25 mm.[43] Gut turned sharply downward above anus.[33]

Pigmentation: Eye pigmented at hatching.[13,43,72] Yolk-sac larvae (size not stated) with numerous chromatophores on ventral surface of yolk sac; many small, stellate chromatophores over lateral and ventral surfaces of body; 2–4 chromatophores usually present on intestine between anus and yolk sac; occasionally 1–2 on lateral margin of lower jaw; a well-developed ventral pigment line from anus to caudal fin, with 1 or more chromatophores per segment; few small chromatophores in visceral pigment line dorsal to yolk sac; 1 or 2 chromatophores along dorsal line in region of caudal fin.[33] By end of stage, body transparent; [13] ventral pigment line enlarged, forming continuous chain of interlocking, stellate chromatophores; 1–5 small chromatophores scattered over notochord.[40]

LARVAE

Size range 9.0 [34] to 17.0 mm [33] or larger.[72]

Total myomeres 38–53 (mean 45), preanal myomeres 16–24 (mean 19), postanal myomeres 22–29 (mean 26).[13,33]

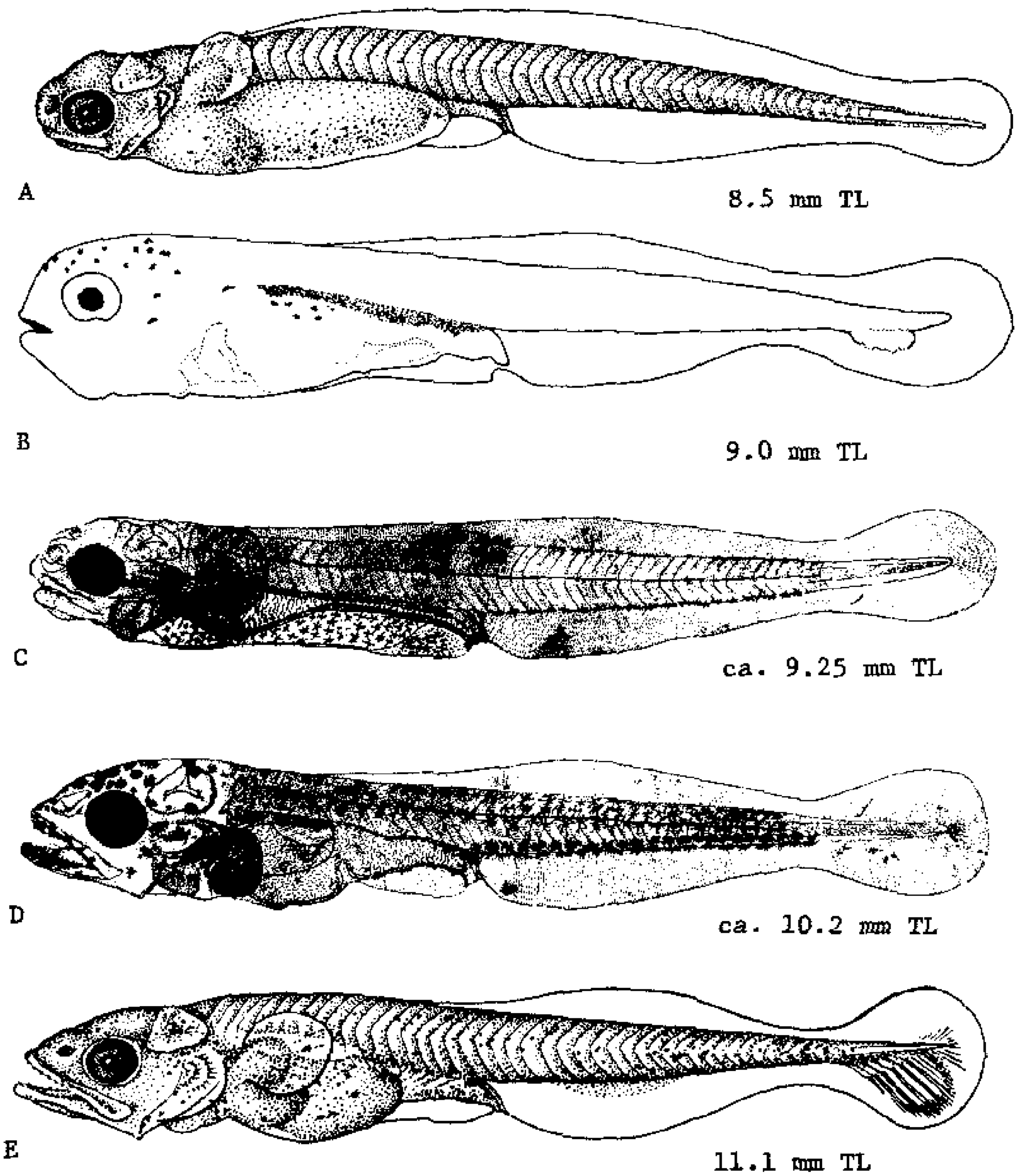


Fig. 207. *Stizostedion vitreum*, Walleye. A. Yolk-sac larva, 8.5 mm TL. B. Yolk-sac larva, 9.0 mm TL. C. Yolk-sac larva, ca. 9.25 mm TL. D. Larva, ca. 10.2 mm TL. E. Larva, 11.1 mm TL. (*A, E, Nelson, W. R., 1968: figs. 4, 5. B, May, E. B., and C. R. Gasaway, 1967: fig. 51, Tamiko Karr, delineator. C, D, Reighard, J. E., 1890: pl. 9.*)

During stage average preanal myomere count increase from 21.2 to 25.0, average postanal myomeres decrease from 25.0 to 20.9.[40] Vertebrae 47 (25 + 22).[13]

Proportions as percent TL: Snout-vent length 45–56 (average ca. 52), caudal peduncle ca. 7.5.[13]

Body slender;[13] articulation of lower jaws located below or behind posterior margin of orbit;[33] teeth large, well-developed,[13] by 10.5 mm evident on premaxillary;[33] anteriormost teeth larger than others, conical, curved.[47] Finfold essentially gone at 13.0 mm. Ossified rays first evident in ventral half of caudal fin at 10.5 mm, in dorsal and anal fin at 13.0–14.0 mm.[33] Anal fin fully formed at ca. 15.0 mm. Pelvics first evident at ca. 15.0 mm in some specimens[13] (although not developed in others at 17.0 mm),[33] ossified in some at 16–17 mm.[33] At 9.5 mm

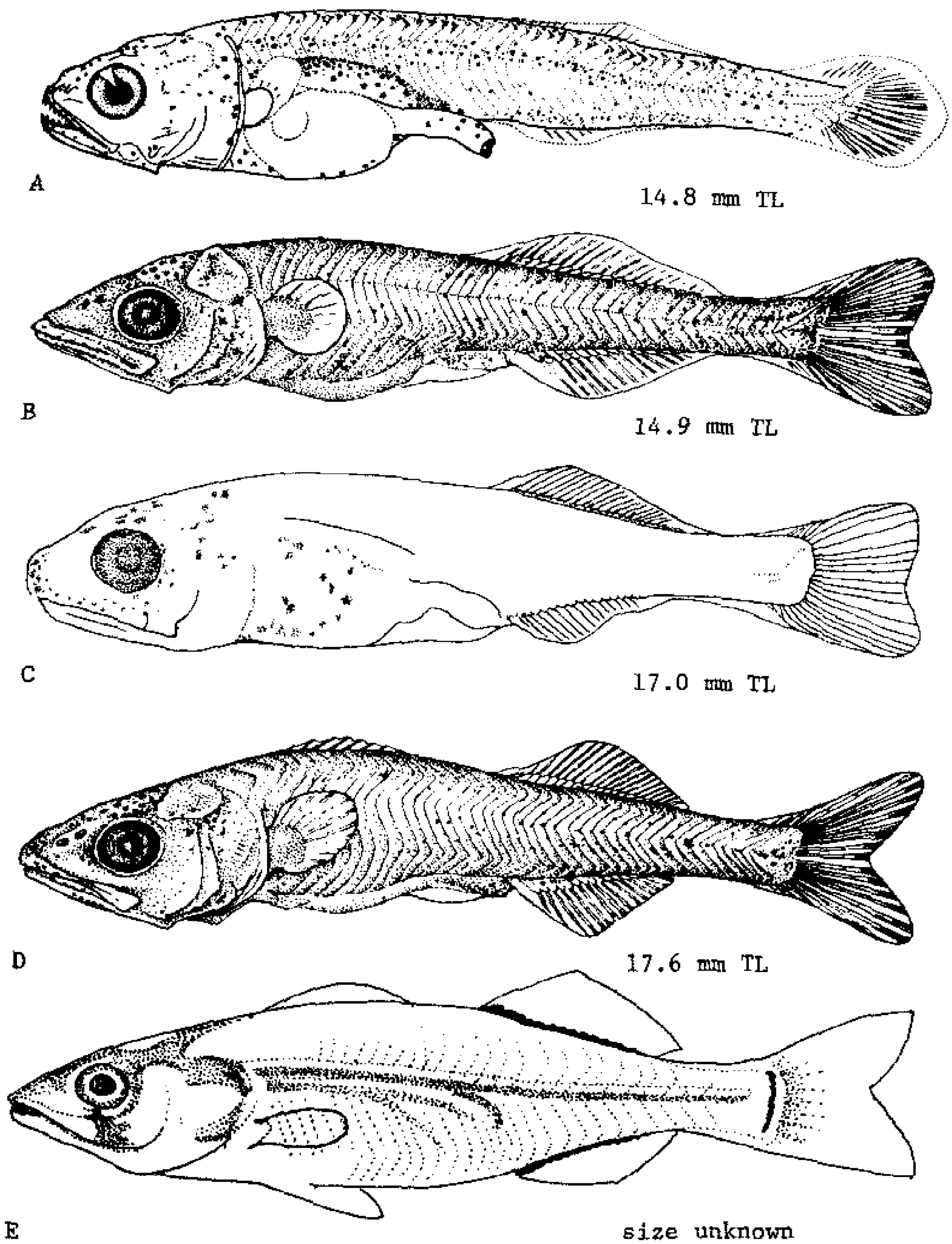


Fig. 208. Stizostedion vitreum, Walleye. A. Larva, 14.8 mm TL. *B.* Larva, *14.9 mm TL. C.* Larva, *17.0 mm* TL. D. Larva, 17.6 mm TL. E. Juvenile, size unknown. (*A, Norden, C. R., 1961: fig. 5. B, D, Nelson, W. R., 1968: figs. 6, 7. C, May, E. B., and C. R. Gasaway, 1967: fig. 52, Joan Ellis, delineator. E, Raney, E. C., 1959: 24, Tamiko Karr, delineator.*)

cleithra, dentaries, premaxillaries, and ceratobranchials beginning to ossify; and at 12.0–13.0 mm opercle, preopercle, frontal, vertebrae beginning to ossify.[33] Urostyle oblique at 12.0–15.0 mm,[13] conspicuously projected at 14.8 mm. Intestine "somewhat coiled" near stomach, essentially straight posterior to stomach, ca. 15% TL.[33]

Pigmentation: Pigment on body diffuse, becoming increasingly so with size and age; two rows of pigment dorsally from head to caudal fin, one along mid-dorsal region of body with 1 or 2 chromatophores per myomere, the other dorsal to notochord with 1–4 chromatophores per myomere; lateral pigment line well-developed, at level with and just below notochord, and with 1–4 chromatophores per myomere; visceral pigment line with numerous chromatophores located dorsal to and around gas bladder; chromatophores numerous above intestine, decreasing in number near anus; 2–6 chromatophores near vent; a ventral pigment line with 1–3 chromatophores per segment from anus to caudal fin; large stellate chromatophores on top of head, from tip of snout to nape, on cheeks, at base of pectoral fin in region of heart; jaws fairly well pigmented.[33] Eye with metallic silver, gold, and copper.[43]

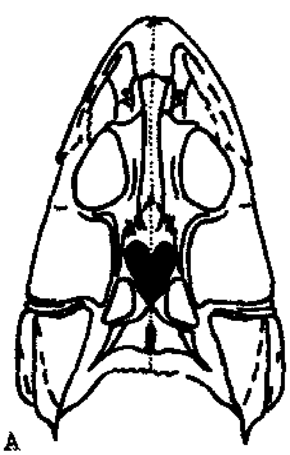
JUVENILES

Minimum size described, 24.0 mm.[16]

In specimens ca. 25–75 mm long, 3–4 pyloric caeca.[62]

Interorbital distance 15.7 percent or more of HL.[74]

Body subcylindrical in "young."[74] Scales first evident at 24 mm, at 40 mm only nape scaleless, at 45 mm completely scaled.[16]



A

Fig. 209. *Stizostedion vitreum*, Walleye. A. Skull of juvenile showing heart-shaped pigment patch on head. (A, *Priegel, G. R., 1967: 109*.)

Pigmentation: In specimens ca. 25–75 mm long, a heavily pigmented black area on dorsal surface of head visible through pariental bone.[62] In specimens ca. 25–350 mm (thus including some adults) vague to obvious dark vertical bands across back and down sides.[74] In "young" eyes brilliant emerald.[6] In a specimen of unknown length, body, first dorsal, and proximal half of 2nd dorsal bright lemon yellow; belly white, dark rows of pigment along dorsal, anal, and caudal base.[45]

AGE AND SIZE AT MATURITY

Males mature at age group I in Oklahoma[36] to age group V in Minnesota[12] and Manitoba;[48] females at age group II in Oklahoma[36] to 6 years in Minnesota[24,53] and Manitoba.[51] Males mature by 246 mm in Oklahoma[36] to ca. 323 mm in Wisconsin.[28] Females at 320 mm in Oklahoma[36] to ca. 439 mm in Wisconsin.[28]

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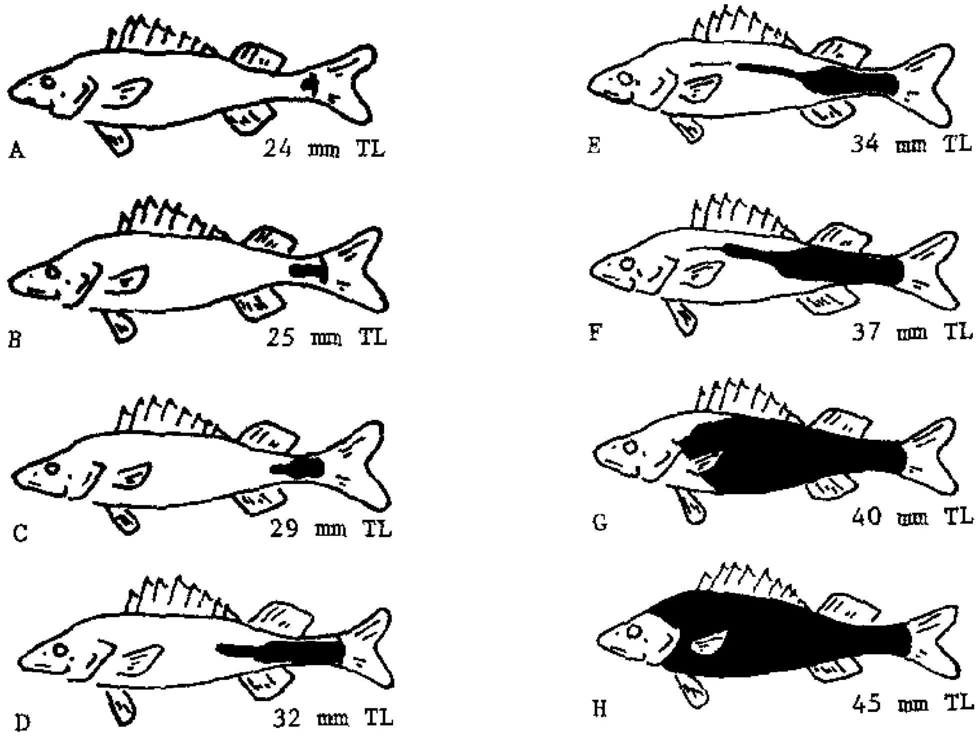

Fig. 210. *Stizostedion vitreum,* Walleye. A-H. Development of scales *through a size range of 24 to 45 mm TL. (A-H, Priegel, G. R., 1964: fig. 1.)*

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Pomatomus saltatrix

bluefishes
Pomatomidae

FAMILY POMATOMIDAE

Most recent authors have included only a single species, *Pomatomus saltatrix*, in the family Pomatomidae. Nelson (1976), however, included two genera, *Pomatomus* and *Scombrops*, and "about three species." The bluefishes are primarily marine fishes, but sometimes enter estuarine areas in large numbers. They are found in tropical and temperate parts of the Atlantic, Indian, and Pacific oceans (although *Pomatomus saltatrix* is absent from the central Pacific and has been reported only once in the eastern Pacific), as well as the Mediterranean and Black seas.

These fishes have a membranous flap over the suboperculum. The soft dorsal and anal fins are covered with scales, the dorsal fins are separated, and there is a distinctive black blotch at the base of the pectoral fin.

Eggs of the bluefish, as described from the western North Atlantic and the Black Sea, vary from 0.8 to 1.2 mm in diameter. They have a single large oil globule, a rather narrow perivitelline space, and a homogenous yolk.

The larvae hatch at 2.0 to 2.4 mm and yolk absorption takes place at about 3.3 to 3.6 mm. Important larval characters are the protrusion of the yolk anteriorly beyond the head in recently hatched individuals; the relatively short, uncoiled intestine; the broad dorsal finfold which often extends well onto the head; and the presence of pigment along the dorsal and ventral ridges of the body and over the posterior part of the intestine. The anus is initially located at or a little beyond the midpoint of the body. It then shifts forward to a point about one-third along the body length, and in later stages, shifts posteriorly again to or beyond the midpoint. In specimens from the western North Atlantic the oil globule is in the extreme posterior part of the yolk sac, while in the Black Sea it may be at the center of the yolk sac.

Sparta (1962) described and illustrated (figs. 215, 218) a series of eggs and larvae from the Mediterranean Sea, and attributed them to *Pomatomus saltatrix*. The eggs in this series are larger than those of the Black Sea and western North Atlantic bluefish populations and have granular rather than homogenous yolks. Furthermore, hatching took 72 hours from the time of embryo and myomere formation (total incubation period unknown) compared to total incubation periods of 44 to 46 hours otherwise reported for the bluefish. Larvae of the Mediterranean series retained prominent yolk sacs at 4.92 mm while the yolk was completely lost in the western North Atlantic and Black Sea populations at 3.3 to 3.6 mm. They differed also in having the intestine much longer, pigment under rather than over the posterior part of the intestine, prominent pigment bars along the posterior edges of the dorsal and ventral finfolds, the eye barely pigmented dorsally at 4.92 mm (eye well pigmented throughout at 2.9 to 3.1 mm in Black Sea and western North Atlantic), and no vertical fin rays at 5.52 mm (otherwise vertical rays developing at 4.3 to 5.0 mm). It is unlikely that the Mediterranean eggs and larvae are those of *Pomatomus saltatrix*.

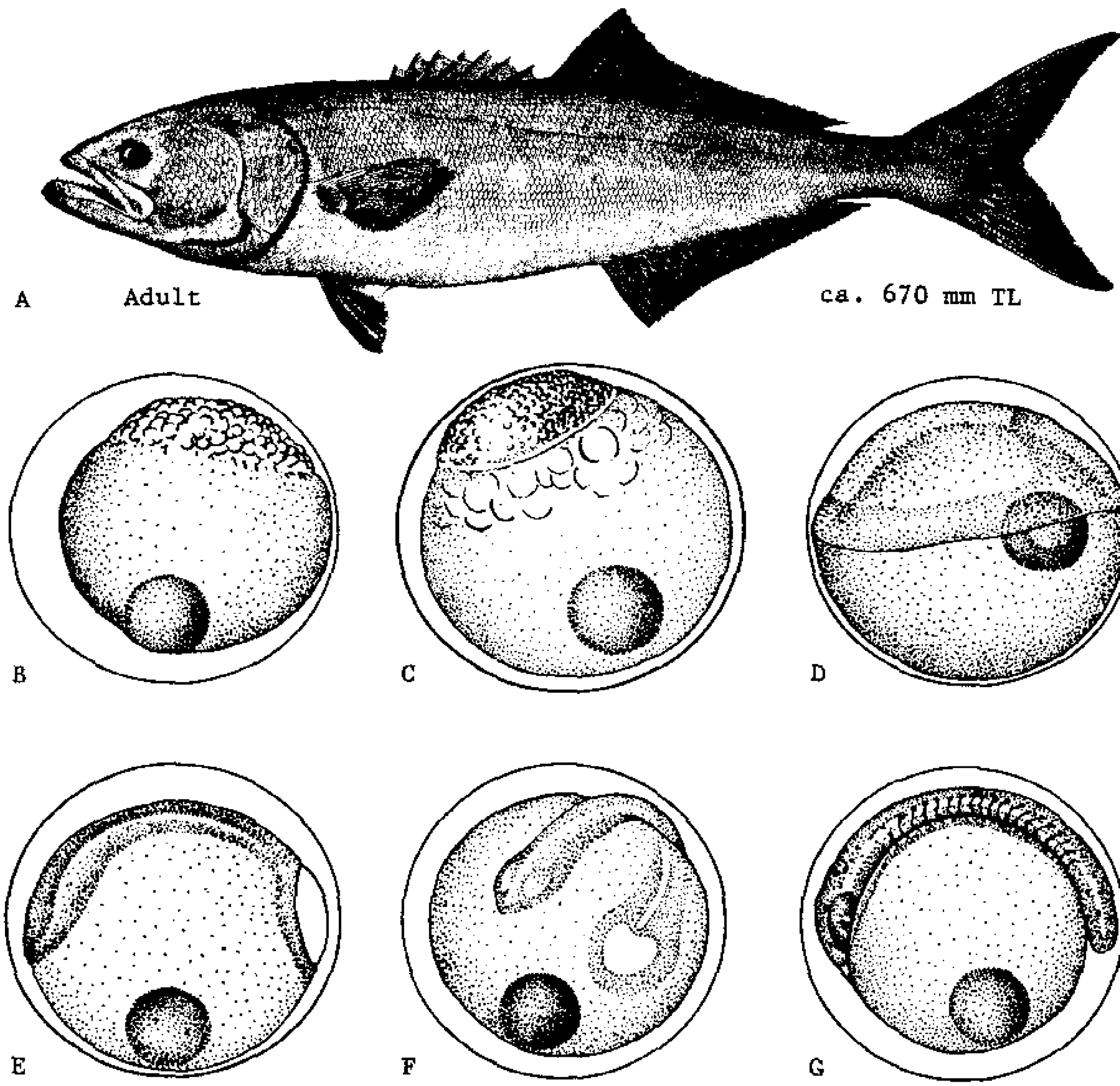

Fig. 211. *Pomatomus saltatrix*, Bluefish. A. Adult, ca. 670 mm. B-G. Egg development, western North Atlantic. B. Early morula, 5 hours. C. Late morula, 9 hours. D. Gastrula, 16 hours. E. Embryonic axis formed, 17 hours. F. Eyes forming, 20 hours. G. Tail free, 20 myomeres, 21 hours. (*A, Goode, G. B., 1884: pl. 174. B-G, Devel, D. G., et al., 1966: figs. 1, 2.*)

Pomatomus saltatrix (Linnaeus), Bluefish

ADULTS

D. VII [10] to IX,[1,8,26] 23–28; A. II [1,10] (or III),[8,26] 23–29 (based on "young" fish); lateral line scales 88–104 (based on "young"),[15] scales between origin of first dorsal and lateral line, 6, between origin of anal and lateral line, 17;[20] vertebrae 11 + 15;[1,8] gill rakers lower limb first arch 11–14 [28] (3 + 11 in western Atlantic, 3 + 8 in Africa [15]).

Proportions as times in TL: Head 4, greatest depth, 5.[10] Proportions as times in SL: Head 3.1–3.5, depth 3.1–ca. 4.0.[26,28]

Body oblong, stout, somewhat compressed; head rather blunt,[10] naked above;[20] preopercle serrate;[28] lower jaw projecting; gape to middle [10] or posterior margin of eye.[20] Upper and lower jaws with single row of stout, conical teeth. Lateral line slightly elevated above pectorals. Caudal fin forked;[10] 2nd dorsal more than twice as long as 1st;[30] anal spines usually hidden in skin.[10]

Pigmentation: Sea green or greenish blue above, a black or dusky blotch at base of pectorals.[10,20] First dorsal and caudal fin dusky, second dorsal olive green; anal fin white along base, distal half translucent and with punctulations; pelvics white; pectorals yellowish green with dark bases [28] (2nd dorsal, caudal, and pectorals also described as having "same general tint as body" [30]).

Maximum length: 933.5 mm.[10]

DISTRIBUTION AND ECOLOGY

Range: In the western Atlantic, Nova Scotia to Argentina (40° S) including the Gulf of Mexico and Bermuda. In the northeast Atlantic, northwestern Africa and the Canary Islands. Also known from the eastern Mediterranean, the Black Sea, both coasts of southern Africa, Madagascar, Tasmania, the Malay Peninsula, eastern Indian Ocean, southern Australia, and New Zealand.[10,15,18,44] Fowler has reported a single specimen from the eastern Pacific along the coast of Chile.[15]

Area distribution: Throughout Chesapeake Bay,[20] Maryland and Virginia seaside,[33,34] Delaware Bay,[30] coast of New Jersey.[42]

Habitat and movements: Adults—a pelagic, schooling species [10] (sometimes forming schools 6 to 8 km long [30]), with schooling behavior correlated with light.[3] Depth, possibly to 100 m.[15] Distance out, at least 148 km.[1] Occasionally ascend brackish portions of rivers. Minimum salinity, ca. 7.0 ppt.[37] Minimum temperature, probably 14.5 C, although possibly as low as 10 C (a suggested minimum of 4.5 C [15] is questioned, JDH).

Various authors, working on the Atlantic coast of North America, have suggested either north-south or inshore-offshore annual movements or both in this species.[10,11,14,17,27,28,30] Occurrence of specimens (size and age unspecified) along the coast of South Carolina and Georgia throughout the year,[4] and winter records of adults in the northeast (Martha's Vineyard and Hudson Gorge) [11] and at the outer edge of the continental shelf off New Jersey [44] support the inshore-offshore theory. On the other hand, tag recapture data strongly support a general north-south movement [12] and long distance migrations have been recorded, as, for example, from New York to Mantanzas, Cuba [30] and from Virginia to Gulf coast of Florida.[12] Records of arrival and/or departure from various localities are as follows: offshore in Gulf of Mexico during much of year;[7] inshore in Louisiana in summer;[13] in Florida arrive in autumn, depart in spring,[21] with large numbers still off southern Florida in March;[44] arrive in North Carolina in March and April;[17,28] in Virginia, Maryland, and Chesapeake Bay area inshore May to August and again, in some years, in September

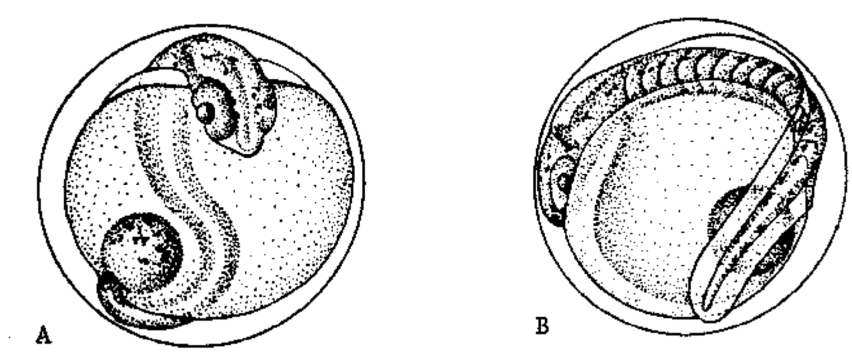

Fig. 212. *Pomatomus saltatrix*, Bluefish. A. Advanced embryo, 30 myomeres, 37 hours. B. Embryo just before hatching, 45 hours. (*A-B, Deuel, D. G., et al., 1966: fig. 2.*)

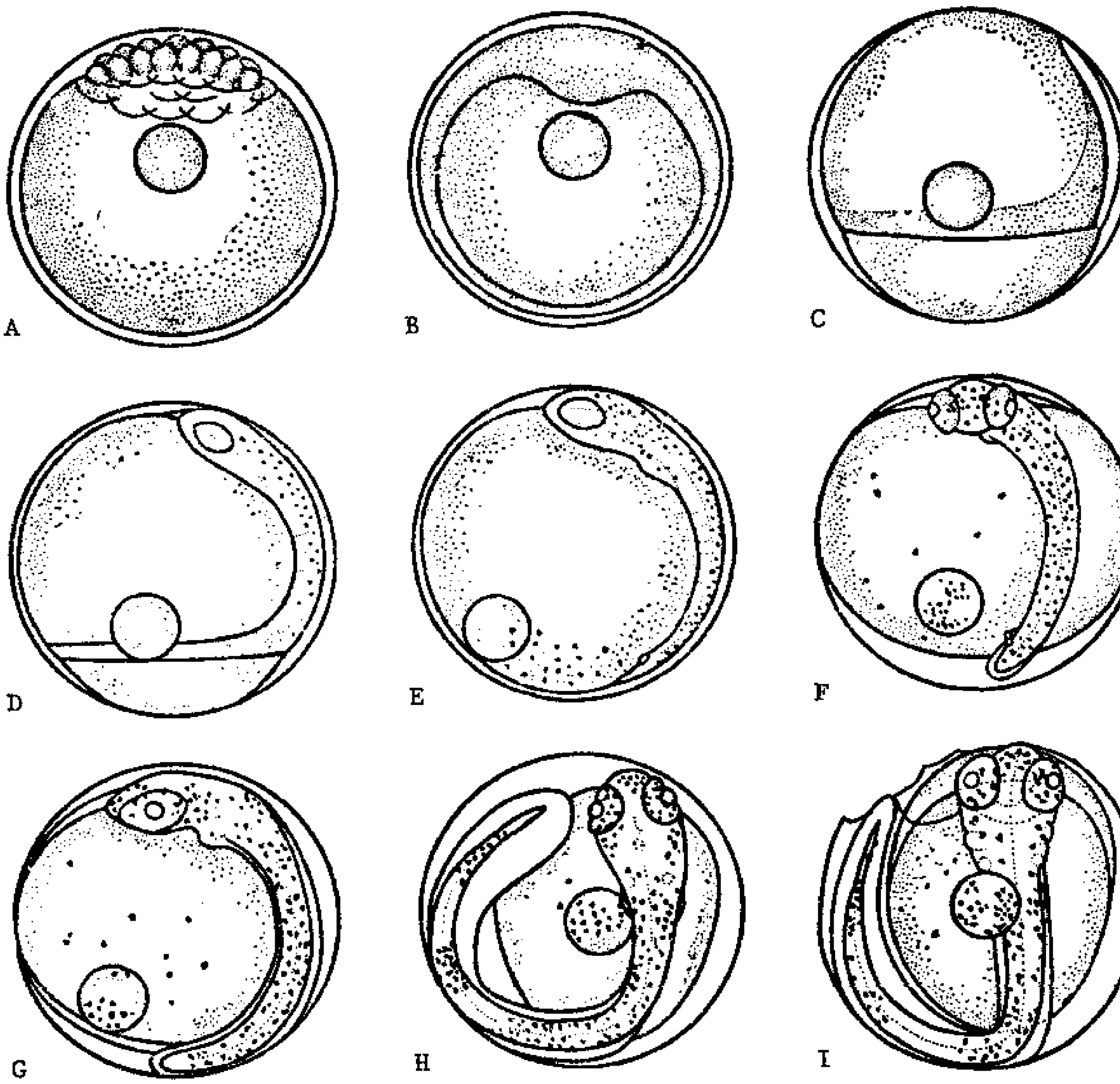

Fig. 213. *Pomatomus saltatrix*, Bluefish. A-I. Egg development, Black Sea. A. Early morula. B. Gastrula. C. Blastoderm over three-fourths of yolk. D. Eye forming, pigment on body. E. Additional pigment on yolk. F. Lens formed, pigment on oil globule. G. More advanced embryo. H. Otocysts formed. I. Embryo at time of hatching (note apparent lack of otoliths). (*A-I, Dekhnik, T. V., 1973: fig. 20.*)

and October (the midsummer inshore low may relate to either offshore spawning or northward migration); [2] in New Jersey–Long Island area inshore April, May, or June, or when surface temperatures reach 12–15 C, depart end of November; in Massachusetts and New Hampshire, arrive in late May or June.[1,17,28] In Europe move from Sea of Marmova and Aegean Sea into Black Sea in spring, breed there, return in fall.[9,45]

Larvae—greatest concentrations of larvae reported from 82 km offshore to within 24 km of edge of continental shelf,[1] although small larvae (4–7 mm) also reported just inside Chesapeake Bay.[22] At or near surface (in rearing experiments remained at surface for first hour or so, then moved to midwater or bottom of hatching container). At hatching float upside down at ca. 45° angle with head down but with tail nearly horizontal.[1,21] Minimum temperature, probably 21 C.[23] Larvae hatched off Chesapeake Bay carried offshore and south.[1]

Juveniles—found in both inshore [1,19] and offshore waters.[6,41] Inshore along ocean beaches, and in inlets, estuaries, creeks, and rivers [1,32,37] in both clear and turbid water, over bottoms of sand and gravel.[5,16] May ascend considerable distances up rivers, as for example, 135 km up Rappahannock River, Virginia, from mouth of Chesa-

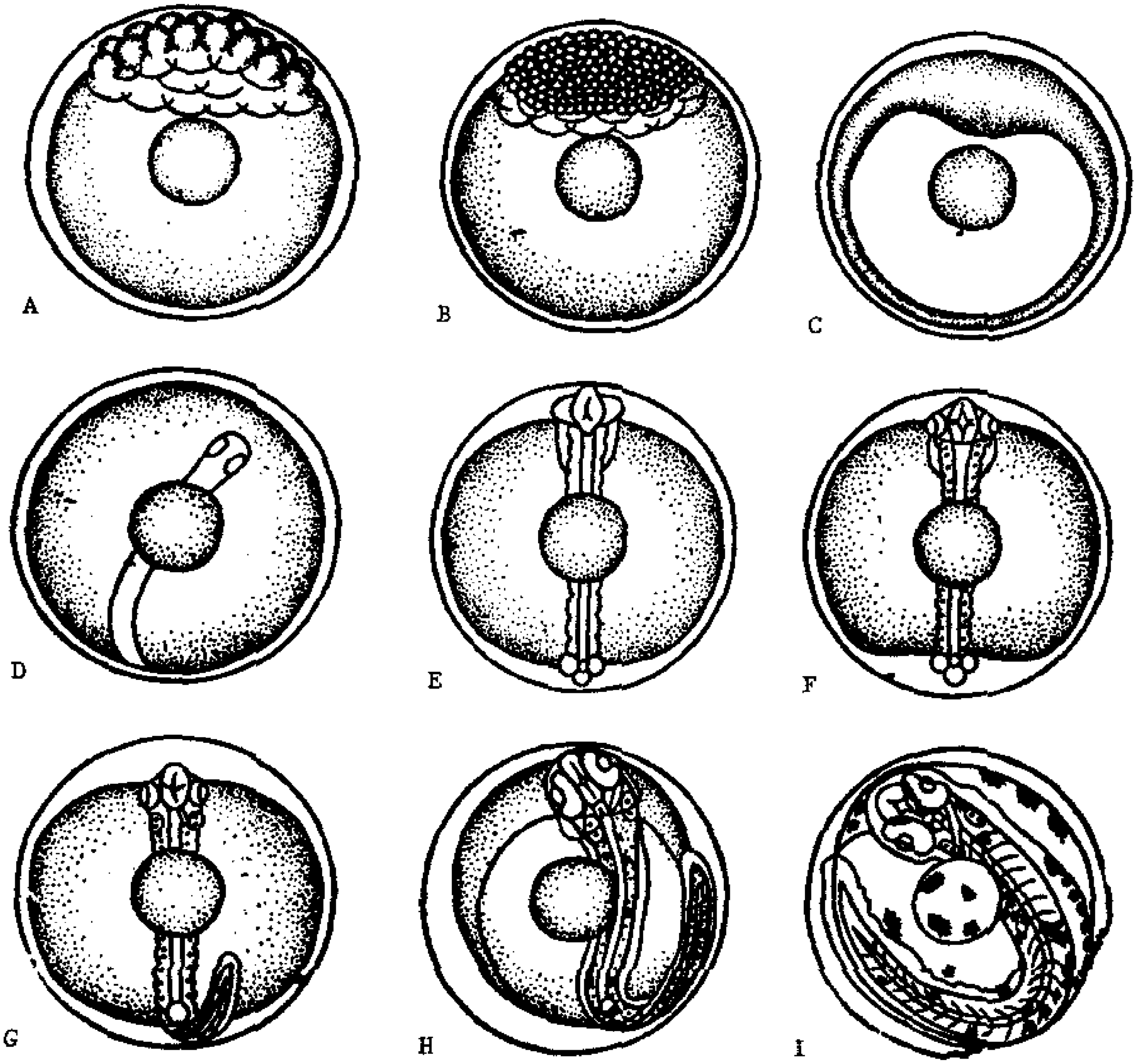

Fig. 214. *Pomatomus saltatrix*, Bluefish. A-I. Egg development, Black Sea. A. Early morula, 2 hours. B. Late morula, 6 hours. C. Gastrula, 10 hours. D. Eyes developing, 19 hours. E. Somites forming, 25 hours. F. Pigment developed on body, 28 hours. G. Tail free, otoliths formed, 37 hours. H. Pigment consolidated into large blotches, 43 hours. I. Hatching, 46 hours. (*A-I, Salyehova, L. P., 1959: fig. 1.*)

peake Bay,[1] and to Newcastle on the Delaware River.[32] Individuals as small as ca. 38–50 mm long swim in large schools.[20] *Maximum depth, possibly to thermocline.*[1] Distance out, specimens 14–16.5 mm long reported ca. 96 km offshore,[6] specimens less than 80–100 mm long in "fairly deep water" far from shore.[41] Salinity range 0.0–37.5 ppt.[3,5,9,16] Temperature range 15.2–31.2 C.[16,31]

Young-of-the-year move inshore as the growing season *progresses.*[1] Arrive on Texas coast (at lengths of 46–56 mm) in November; [24] enter Chesapeake Bay and its tributaries in late summer and fall (although "younger fish" are in the bay throughout the summer); [27] inshore in Delaware about mid-June; [5] in New Jersey (at sizes of *ca. 30–37 mm) from mid- to late August;* [17,39] *at Long* Island from late September to mid-October; [29] in lower Hudson River in late summer and fall; [25] in New Hampshire (at sizes of ca. 25–50 mm) in June and early July; and at Woods Hole (at lengths of 75 mm) in early July.[17] Immature fish apparently stray further north along the North American coast than adults.[10] In Black Sea "fingerlings" approach shore at water temperatures of 18.0–24.5 C and move offshore at temperatures of 13–15 C.[15] Some "young" overwinter in the Black Sea; [3] adults do not.[9]

SPAWNING

Location: Primarily over outer half of continental shelf [1] at maximum distance of 160 km from land [21] and possibly at "depth." [30] Norcross, *et al.*, collected 80% of their eggs in offings of Chesapeake Bay from stations more than 55.6 km offshore, but also recorded eggs from extreme southern Chesapeake Bay.[1] Goode recorded both ripe and spent bluefish in vicinity of Martha's Vineyard,[20,38] and ripe bluefish have been recorded inshore in Long Island.[21,23] Lund assumed that spawning occurs throughout the range of the species along the east coast of the United States.[1] In Europe spawning occurs in the Black Sea, after which the adults return to the Sea of Marmara and the Aegean Sea.[9]

Season: Probably over a protracted period throughout range but apparently quite abbreviated in specific localities. Probably five months earlier in Florida than in more northern localities.[2,19] In Texas either a short spring or fall season; [24] in Virginia and offings of Chesapeake Bay June, July, and August, possibly also May; [1,35] ripe females off Delaware and Long Island in August; [5,21] in Black Sea in "spring." [9] Suggestions of winter spawning [17,38] are questioned (JDH).

Time: Peak activity probably near sundown (1900–2100 hrs.).[1]

Temperature: 18.0–26.3 C (based on presence of eggs).[1]

Salinity: 26.6–34.9 ppt (based on presence of eggs).[1]

Fecundity: Ca. 112,000–195,000 [41,43] (a reported minimum of 12,000 [15] is presumably in error, JDH).

EGGS

Location: Surface.[21]

Fertilized eggs: Transparent; diameter 0.80–1.20 mm (in Long Island Sound 0.90–1.20, $\bar{x}=1.00$ mm; [21] in Black Sea 0.80–1.05 mm) [43] egg membrane thin, perivitelline space ca. 1/6 yolk radius; yolk pale amber; oil globule deep amber, diameter 0.22–0.30 mm (mean 0.25 mm).[21]

EGG DEVELOPMENT

Development at 18.0–22.2 C, $\bar{x}=20.0$ C (North America, Devel, *et al.*):[12]

2 hours	64-cell and early morula stages.
5 hours	Early morula.
9 hours	Late morula, individual cells still distinguishable.
14 hours	Blastoderm around 1/3 yolk, oil globule typically under blastodermal tissue, germ ring small.
16 hours	Blastoderm 1/2 around yolk; blastocoel, germ ring, and embryonic shield apparent.
17 hours	Embryo well defined, blastopore open.
20 hours	Notochord, eyes evident; blastopore open or closed; forebrain evident; light pigment on embryo.
21 hours	20 myomeres; tail free; embryo around 1/2 yolk; 3 brain divisions visible; nasal pit formed; black pigment on oil globule, in two rows along each side of notochord, and around eyes.
34 hours	Heartbeat established.
37 hours	Pigment as in previous stage, but an additional row of pigment along ventral aspect of tail; finfold well-developed; ca. 30 myomeres; oil globule near anus; movements noticeable in tail.
40 hours	Tail lengthened; eyes unpigmented; choroid fissure, auditory vesicles formed; finfold enlarged and flattened.
42 hours	Convulsive movements of body; oil

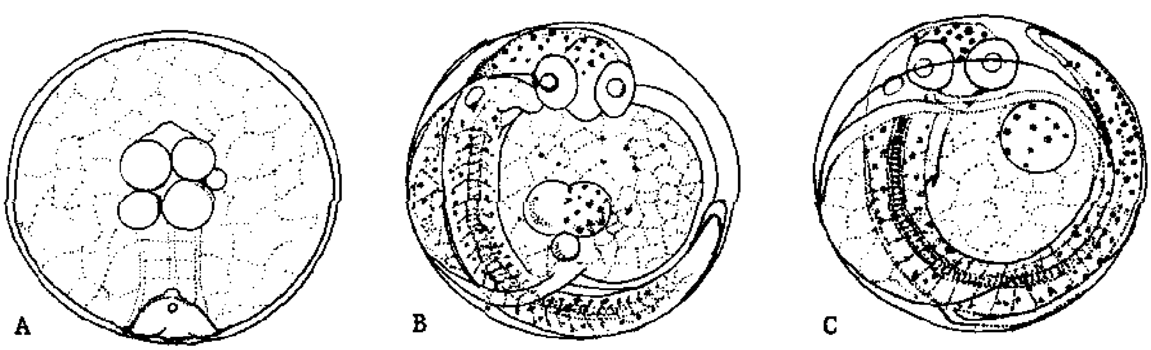

Fig. 215. *Pomatomus saltatrix*, Bluefish. A-C. Egg development, Mediterranean Sea. A. Egg, age unknown, well formed embryo (note multiple oil globules and vesicular yolk). B. The same egg, 24 hours later, lens formed, pigment on body, yolk, and oil globule. C. The same egg, 72 hours after A. *(A-C, Sparta, A., 1962: pl. I, Joan Ellis, delineator.)*

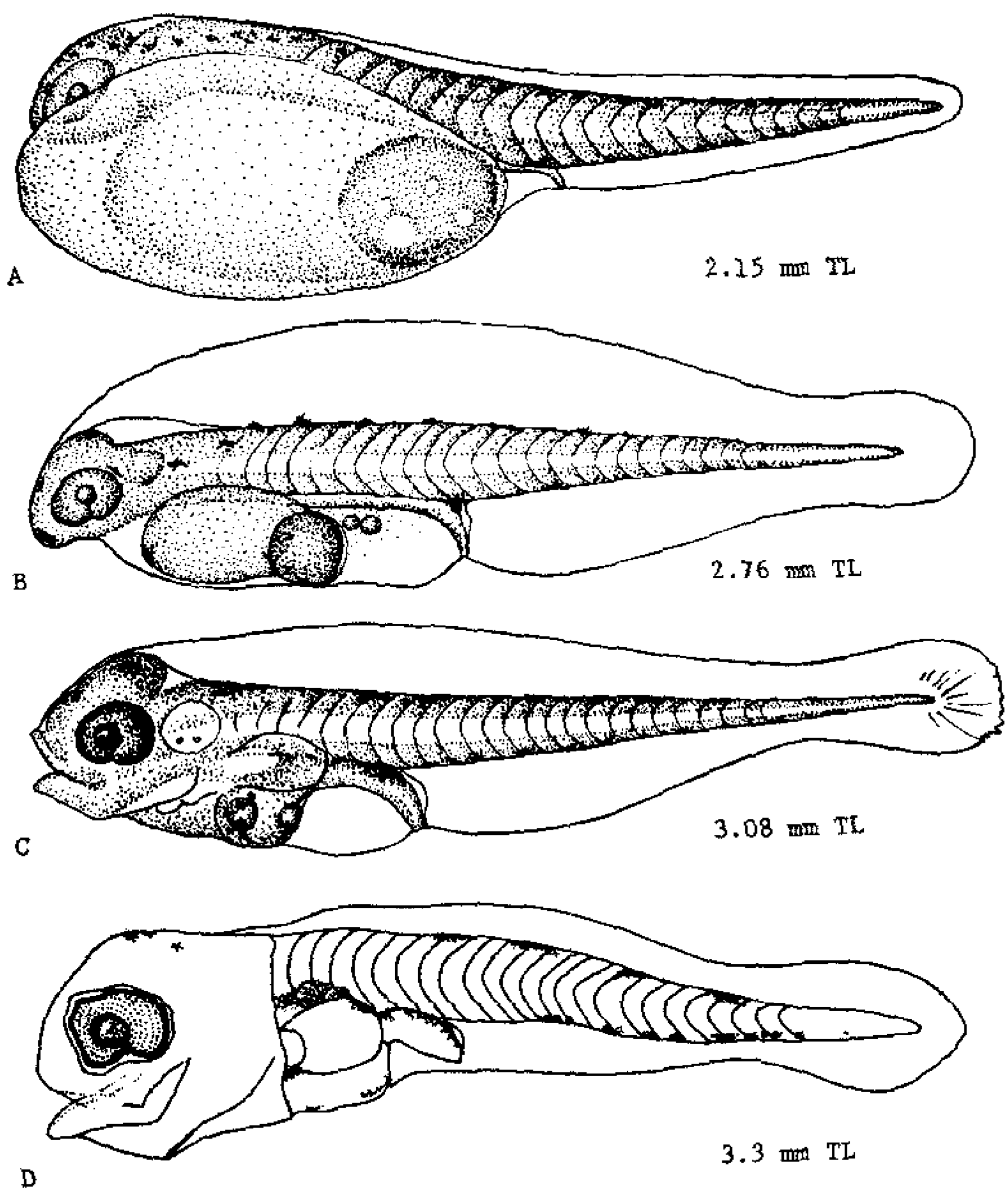

Fig. 216. *Pomatomus saltatrix*, Bluefish. A-D. Northwest Atlantic specimens. A. Yolk-sac larva, 2.15 mm TL. B. Yolk-sac larva, 2.76 mm TL. C. Yolk-sac larva, 3.08 mm TL. D. Larva, 3.3 mm TL, pigment developed over gas bladder. (*A-C, Deuel, D. G.,* et al., *1966: fig. 3. D, Redrawn from Norcross, J. J.,* et al., *1974: fig. 2, Joan Ellis, delineator.*)

	globule golden in preserved material.
46–48 hours	Mass hatching.[21]

Development at 21.1–25.6 C (North America, Perlmutter):[23]

At fertilization	yolk apparently granular on one side.
6 hours	Morula stage. Possibly small oil globules in addition to single large one.
14 hours	Embryo over ca. 1/2 yolk.
25 hours	Embryo well differentiated, eyes forming, pigment evident.[23]

Development at 18.5–22.2 C ($\bar{x}$=20.3 C) (Black Sea, Salekhova):[43]

2 hours	16-cell stage.
4 hours	32-cell stage.

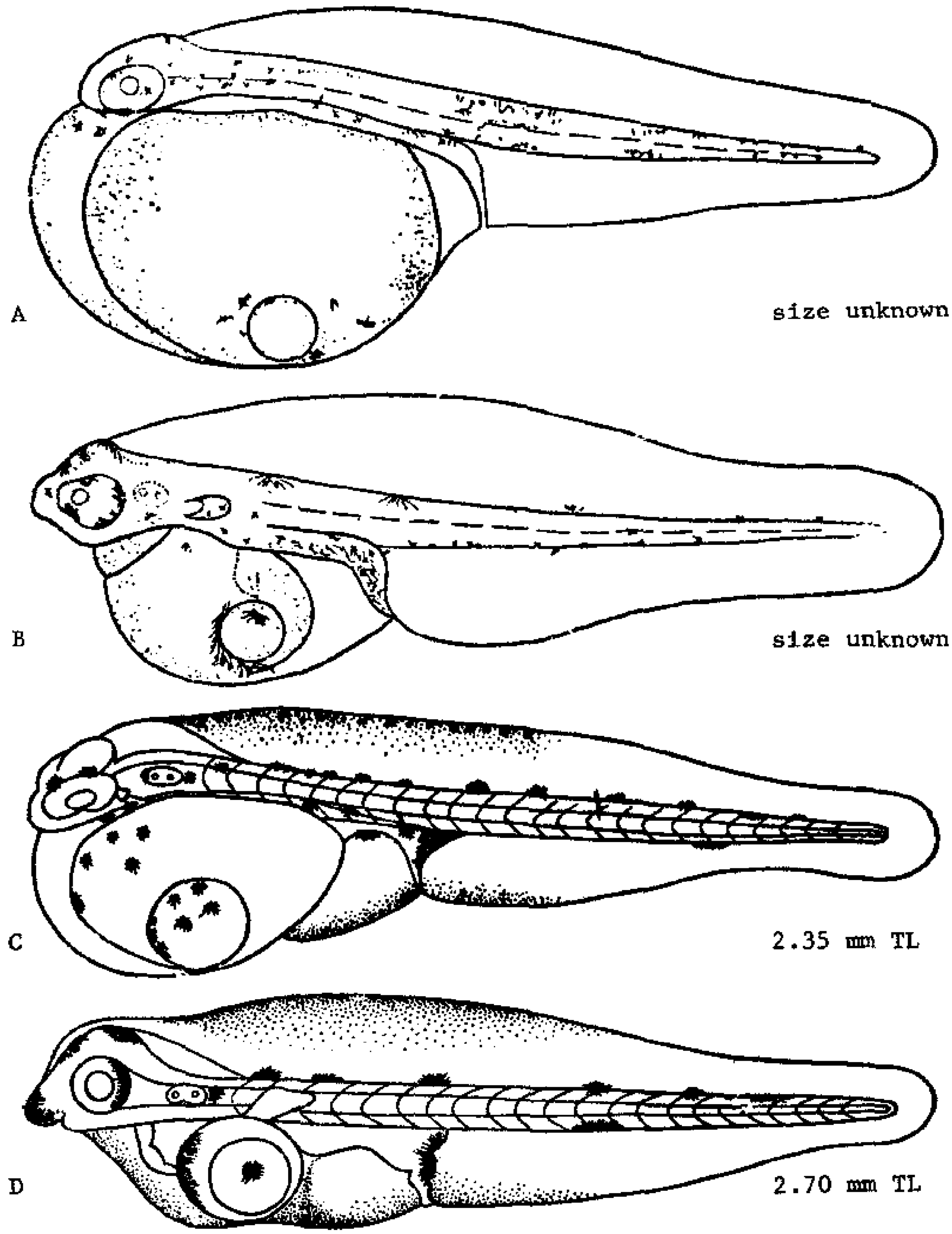

Fig. 217. *Pomatomus saltatrix*, Bluefish. A-D. Black Sea specimens. A. Yolk-sac larva, just hatched, size unknown. B. Yolk-sac larva, 1 day old, size unknown. C. Yolk-sac larva, 2.35 mm TL. D. Yolk-sac larva, 2.70 mm TL. (*A, B, Dekhnik, T., 1973: fig. 21. C, D, Salyehova, L. P., 1959: figs. 3–4.*)

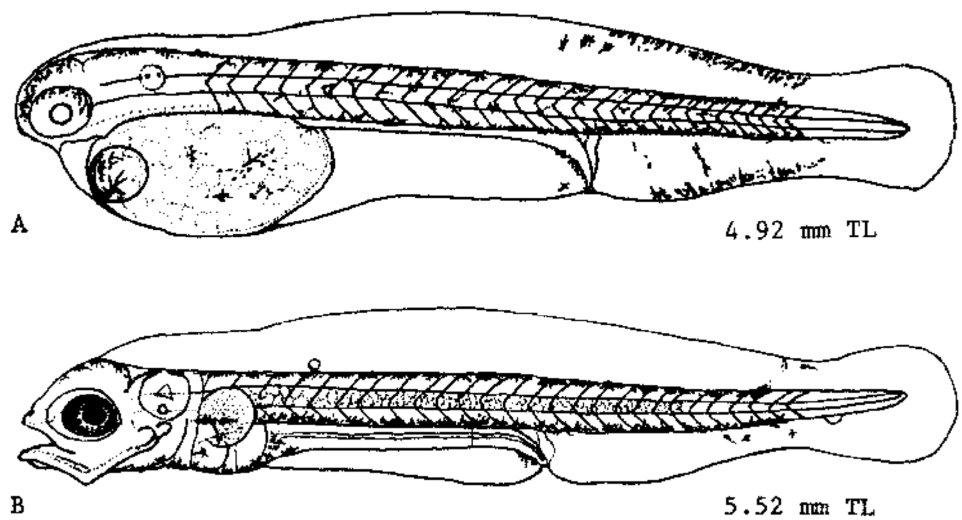

Fig. 218. *Pomatomus saltatrix*, Bluefish. A-B. Mediterranean specimens. A. Yolk-sac larva, 4.92 mm TL. B. Larva, 5.52 mm TL. *(A, B, Sparta, A., 1962: pl. I, Joan Ellis, delineator.)*

10 hours	Gastrulation.
19 hours	Embryo, eyes differentiated.
25 hours	Somites developing.
28 hours	Lenses formed, pigment developed on body.
37 hours	Tail free, otoliths formed.
43 hours	Tail conspicuously longer, pigment patches on body denser.
46 hours	Pigment on oil globule and yolk. Hatching.[43]

Incubation period:

At 18.5–22.2 C ($\bar{x}$=20.3 C), 44–46 hours.[43] At 18.0–22.2 C. ($\bar{x}$=20.0 C), 46–48 hours.[21] Eggs reared at 21.1–25.6 C, but no hatching time stated.[28]

YOLK-SAC LARVAE

Hatching length 2.0–2.4 mm (2.0–2.2 in Chesapeake Bay region,[21] 2.3–2.4 in Black Sea).[43] Maximum size described, 3.08 mm.[21]

Body more elongate, head larger at 3.08 mm (100 hours) than at hatching. Auditory vesicles evident at 2.76 mm, otoliths at 3.08 mm [21] (although developed before hatching in Black Sea specimens [43]). At hatching yolk more than 1/2 length of larva and extended to within 1/2 segment of anus [21] (although only 1/3 yolk length in Black Sea specimens [43]). Yolk 1/2 absorbed at ca. 2.9 mm (2nd day), largely consumed at 3.08 mm (100 hours). Oil globule ca. 1/3 length of yolk, at extreme posterior end of yolk sac in North American populations,[21] at midpoint of yolk sac in Black Sea. Pectoral buds evident in Black Sea population at 2.7 mm,[43] developed (but not illustrated) at 2.76 mm in North American population. Pectoral fins rayless, incipient caudal rays evident at 3.08 mm (100 hours). Urogenital duct developed at 2.76 mm (32 hours).[21]

Pigmentation: In North American populations, at hatching stellate melanophores dorsally in two rows, widely separated on head but converging posteriorly. During first day, in life, yellow and yellow-green pigment spots on dorsal and ventral finfold margin. At 2.7 mm (32 hours) dorsal body melanophores more distinct but less numerous and spread out onto finfold; a conspicuous melanophore between gut and body directly above anus and several melanophores ventrally on body posterior to anus; melanophores present on head, snout, yolk sac and oil globule; eyes unpigmented. At 3.08 mm (100 hours) eyes darkly pigmented, pigment spots on body dark and distinct.[21] In Black Sea specimens, body pigment similar to North American populations, but a conspicuous pigment spot on ventral ridge midway between anus and tail, and pigment developed on yolk-sac, oil globule, and anterior outer edge of dorsal finfold. At 2.7 mm eye pigment developing.[43]

LARVAE

Size range described ca. 3.0 to ca. 14.0 mm.[1]

Total myomeres, 24; preanal myomeres, 9 early in stage, ca. 12 by 8.5 mm.[1]

At beginning of stage, head relatively large, body slender; body depth noticeably increased at 6.0 mm. Eye

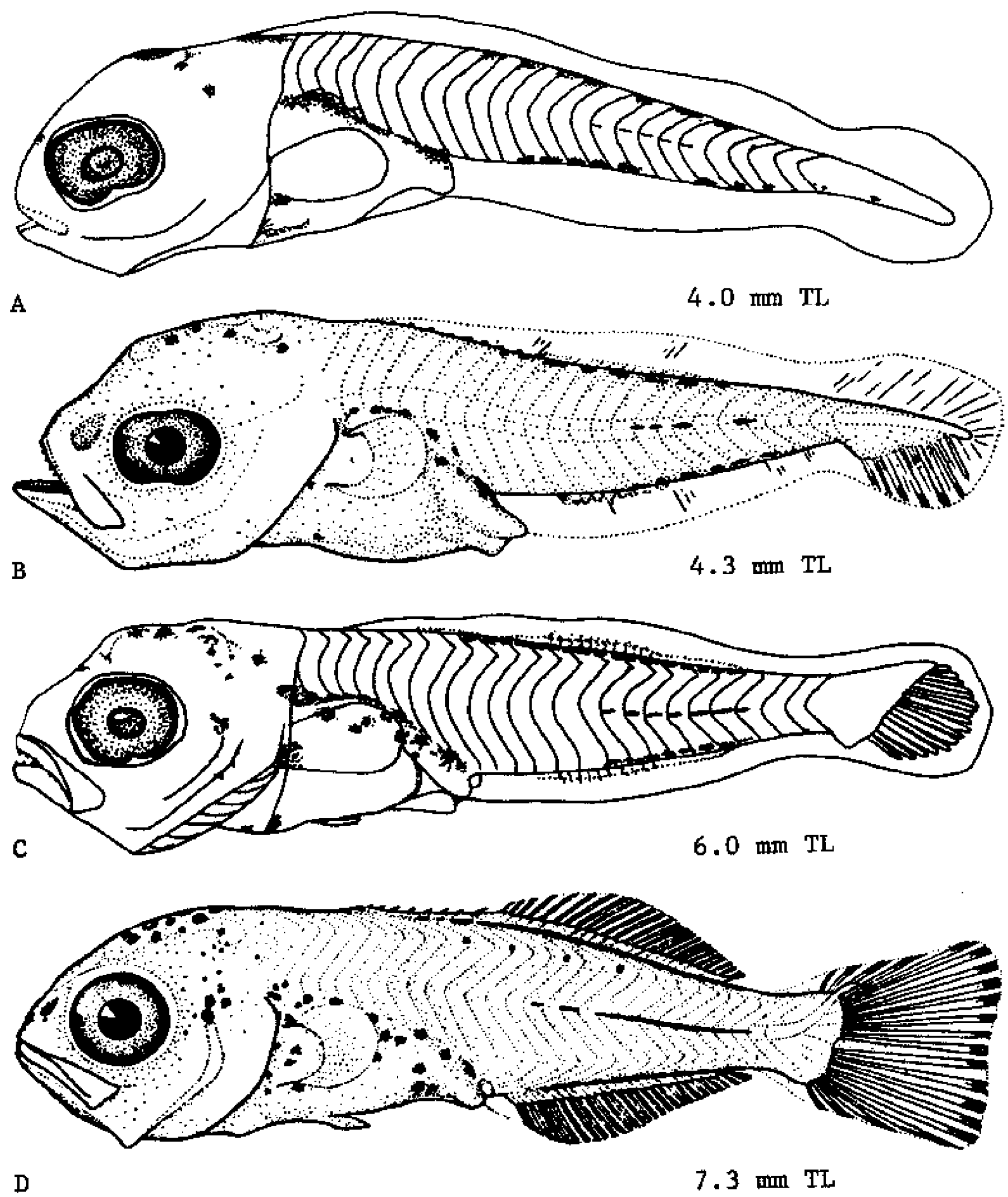

Fig. 219. *Pomatomus saltatrix*, Bluefish. A-D. Northwest Atlantic specimens. A. Larva, 4.0 mm TL. B. Larva, 4.3 mm TL, teeth well formed. C. Larva, 6.0 mm TL, pelvic fins developing, urostyle oblique. D. Larva, 7.3 mm TL, first dorsal forming, urostyle extended into caudal fin. (*A, C, Norcross, J. J.*, et al., *1974: figs. 2–3, Joan Ellis, delineator. B, D, Pearson, J. C., 1941: figs. 12–13.*)

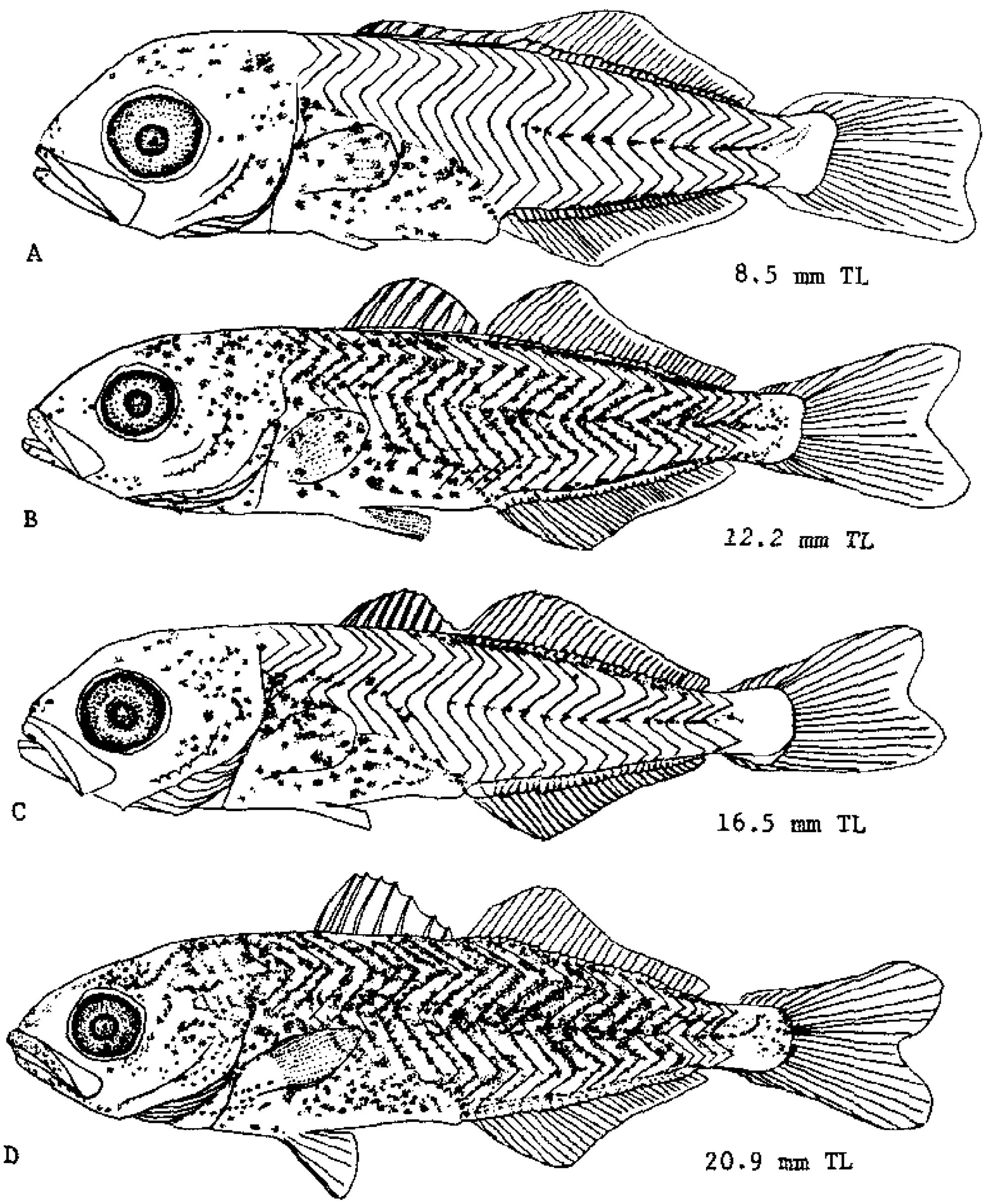

Fig. 220. ***Pomatomus saltatrix***, Bluefish. A-D. Northwest Atlantic specimens. A. Larva, 8.5 mm TL. B. Larva, 12.2 mm TL. C. Larva, 16.5 mm TL. D. Larva, 20.9 mm TL. (*A-D, Norcross, J. J.*, et al., *1974: figs. 3–4, Joan Ellis, delineator.*)

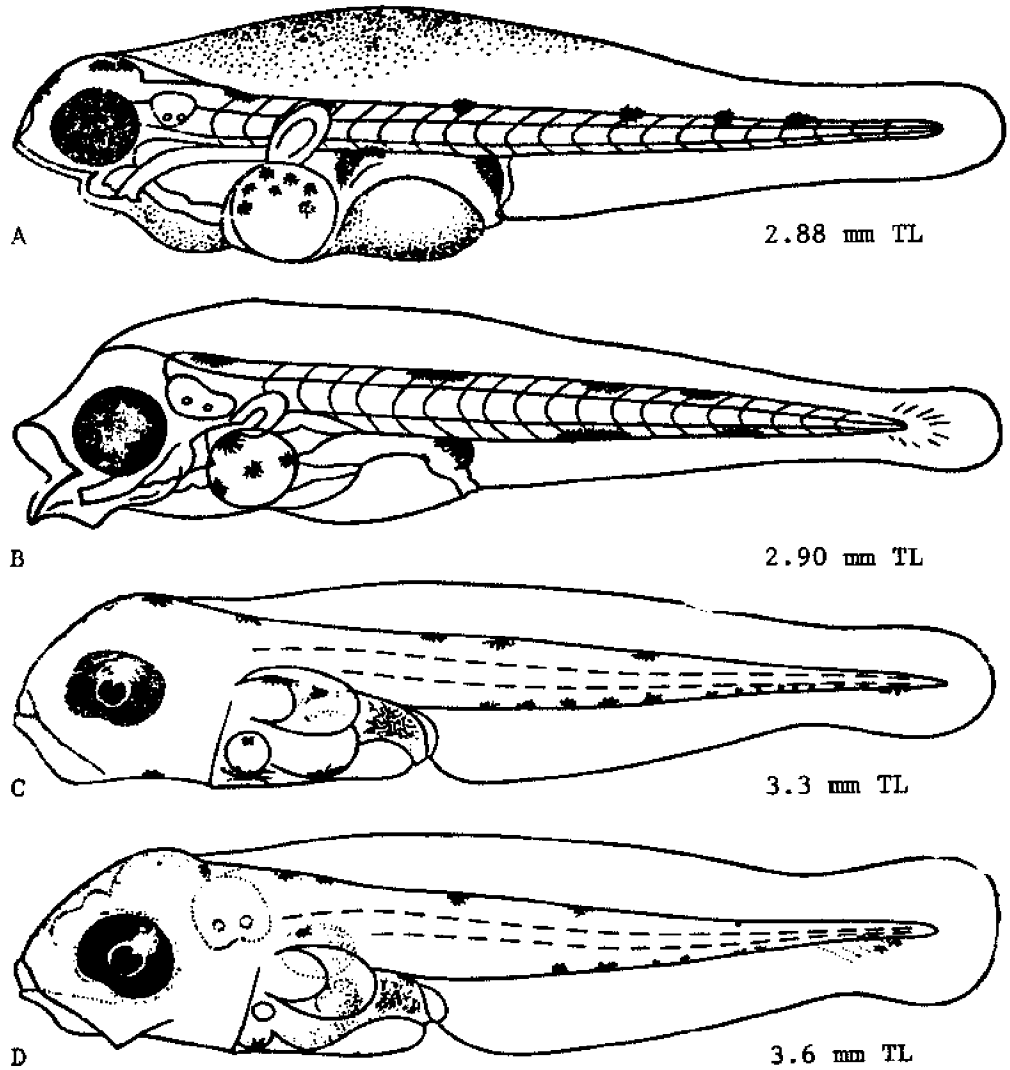

Fig. 221. *Pomatomus saltatrix*, Bluefish. A-D. Black Sea specimens. A. Larva, 2.88 mm TL. B. Larva, 2.90 mm TL. C. Larva, 3.3 mm TL. D. Larva, 3.6 mm TL. (*A, B, Salyehova, L. P., 1959: figs. 4–5. C, D, Dekhnik, T., 1973: fig. 21.*)

initially somewhat elliptical, spherical by 5.0–6.0 mm. Jaws ossified at 4.0 mm.[1] Teeth well-developed at 4.3 mm.[22] Branchiostegal rays first evident at 4.8 mm, full complement formed and ossified at ca. 6.0 mm. Two preopercular spines evident at 4.8 mm, 6 by 9.5 mm, and 7 by 12.8 mm.[1] Incipient dorsal spines and rays evident, but barely so, at 4.3;[22] total spines (8–9) evident at 6.0–6.5 mm; dorsal rays first distinguishable between myomere 13 and 17 at ca. 6.0 mm, full complement at ca. 7.0 mm. Anal rays first evident between myomere 12 and 16 at ca. 6.0 mm, full complement of spines and rays at 7.5 mm. Caudal with 17 ossified principal rays at 5.5–6.0 mm; ossification of secondary caudal rays begun at ca. 6.0 mm, complete at ca. 13 mm. Pectoral ray complement complete at ca. 14 mm. Pelvic buds evident at 6.0 mm or smaller, earliest ossification at ca. 7.0 mm, ossification complete at 8.5 mm. Sequence of first ossification in fins: caudal, second dorsal, anal, first dorsal and pectorals, pelvics.[1] Urostyle straight at 4.3 mm,[22] oblique at ca. 5.0 mm. Neural spines of abdominal vertebrae ossified at 4.5–5.0 mm; at 5.0–5.6 mm neural spines of caudal vertebrae, haemal spines, and centra begin ossification; ossification proceeds anterior to posterior except for ultimate vertebrae which ossifies between 5.5 and 6.0 mm, before penultimate centrum. All centra, including urostyle, ossified at 6.0–6.5 mm. Gas bladder visible at 3.0 mm, no longer evident at 10 mm.[1]

Pigmentation: At 3.0–3.5 mm few stellate melanophores on top of head; several large stellate melanophores on dorsal body surface above cleithrum; a heavy concentration of melanophores over dorsal surface of gas bladder; a conspicuous stellate chromatophore at ventral base of pectoral fin; a double row of single or randomly grouped melanophores along dorsal and ventral ridge postanally; origin of dorsal postanal pigment row at about 6th myomere.[1]

At 4.0–6.0 mm cephalic pigment increased to form a conspicuous cap; dorsal and ventral postanal pigment row more dense, with melanophores coalesced to form relatively solid lines; a lateral pigment band developed, first evident as single melanophores [1] (and in some specimens arranged as short dashes [22]), about one per myomere, between myomere 16 and 20; origin of dorsal pigment row shifted posteriorly to about 9th myomere; origin of ventral pigment similarly shifted posteriorly.[1]

At 5.0–6.0 mm melanophores developed on operculum. At 6.0–8.5 mm pigment over gas bladder and hindgut increased laterally; a few pigment spots sometimes evident at base of caudal.[1]

In specimens sometimes as small as 8.5 mm, scattered melanophores on body between dorsal ridge and lateral line.[1]

At 13.0 mm pigment intensified dorsally and laterally behind the eye, and developed on operculum, snout, upper and lower jaws, and under head.[1]

JUVENILES

Minimum length, ca. 14 mm.[1]

Total myomeres, 24.[1]

Body fusiform at 16.5 mm and larger. Choroid fissure still evident; preopercle serrate at 17.0 mm. Anal fin length equal to 2nd dorsal at 17.0 mm; [1] caudal forked at 26.[23]

Pigmentation: At 16.5 mm and larger, pigment extended from dorsal to ventral body margin, with that on body dorsal to abdominal cavity tending to follow myosepta, and with dorsolateral pigment appearing heavier than ventrolateral pigment.[1]

At 17 mm postanal pigment rows less conspicuous because of increased body pigment.[1]

At 21 mm spotted throughout, with spots tending to follow myosepta, and, apparently, with 2 blotches of pigment at caudal base.[30] At 26 mm lateral bands no longer evident, entire body covered with fine black dots.[21] In life, at ca. 38–50 mm distinctly silvery with posterior edge of caudal dark.[19]

At 72 mm body thickly peppered with fine dots.[22]

AGE AND SIZE AT MATURITY

Minimum age at maturity, during 2nd year in Black Sea.[40] In North America both sexes mature at ca. 300 mm; [21] in Black Sea 140–200 mm.[40]

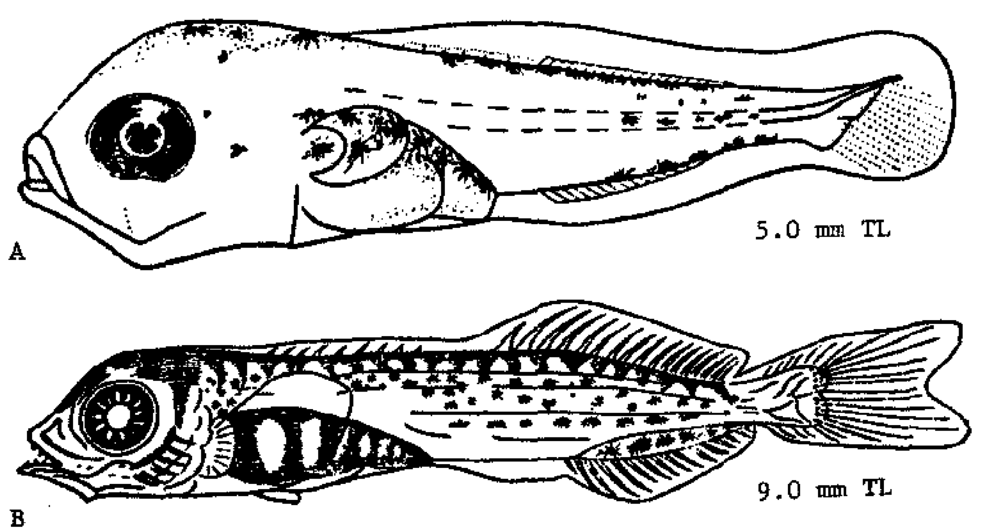

Fig. 222. *Pomatomus saltatrix*, Bluefish. A-B. Black Sea specimens. A. Larva, 5.0 mm TL. B. Larva, 9.0 mm TL, pelvic fins forming. (*A, Dekhnik, T., 1973: fig. 21. B, Salyehova, L. P., 1959: fig. 6.*)

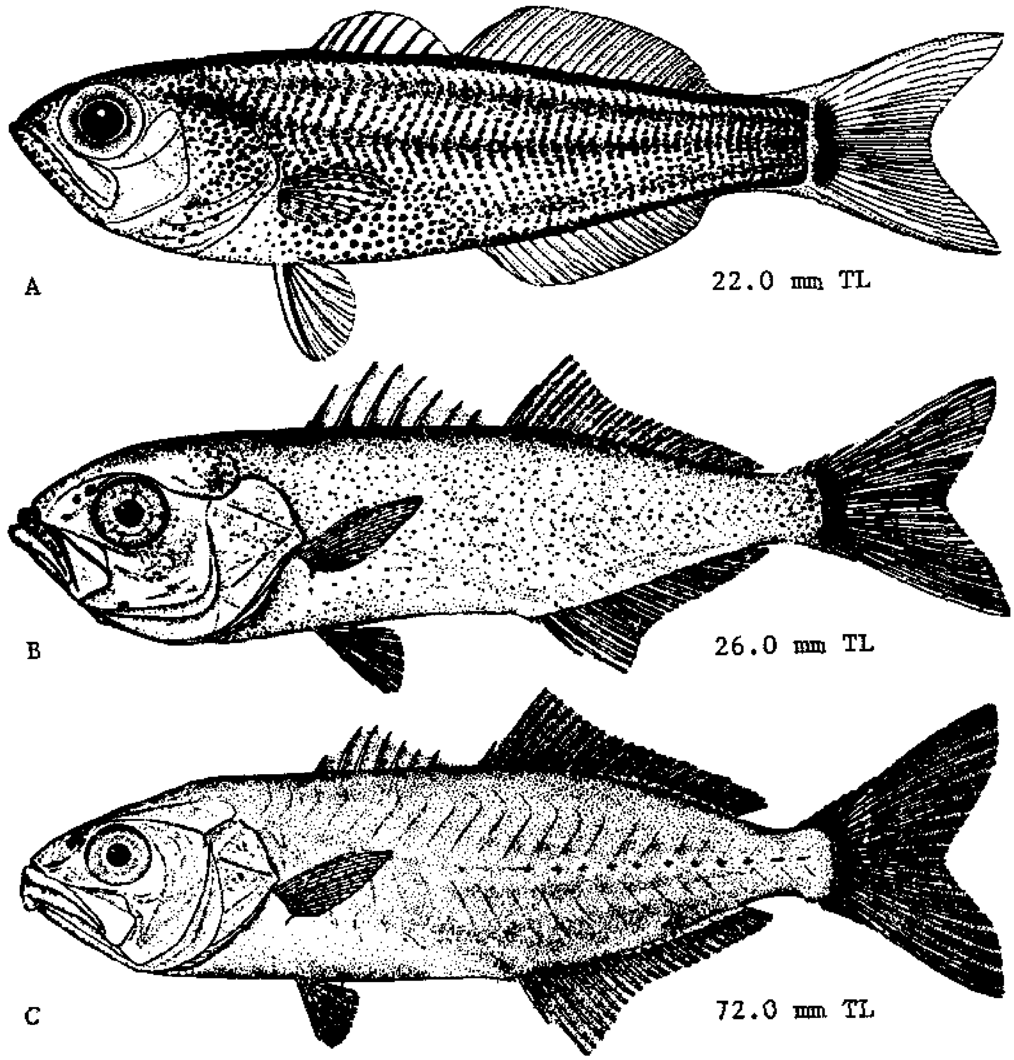

Fig. 223. *Pomatomus saltatrix*, Bluefish. A-C. Western Atlantic specimens. A. Juvenile, 22.0 mm TL. B. Juvenile, 26.0 mm TL. C. Juvenile, 72.0 mm TL. (*A, Fowler, H. W., 1945: fig. 310. B-C, Pearson, J. C., 1941: figs. 14–15.*)

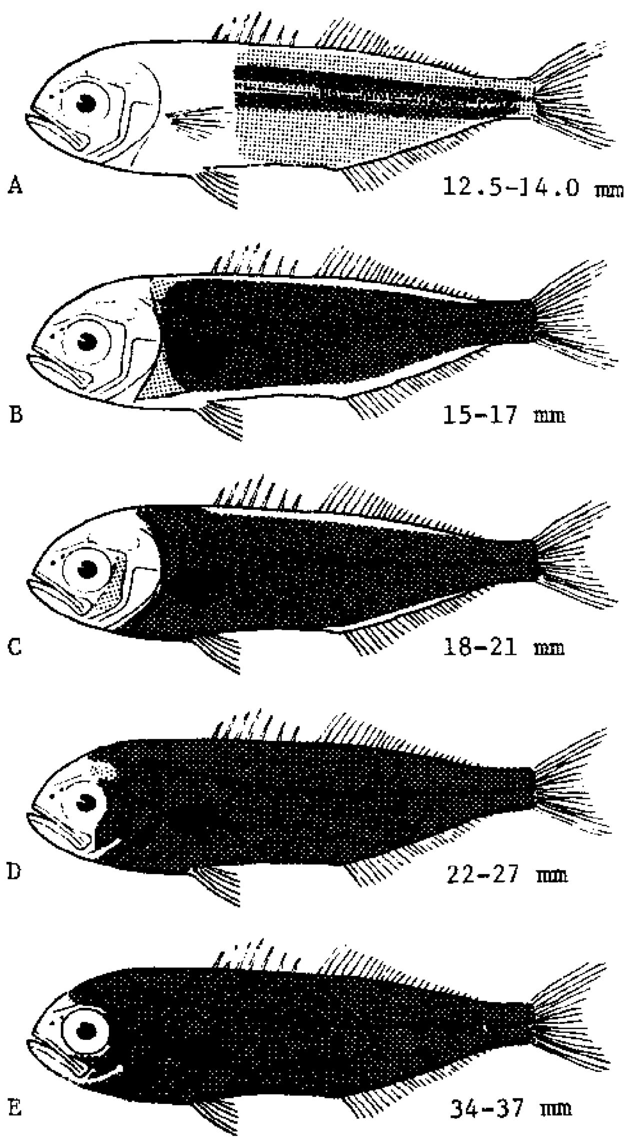

Fig. 224. *Pomatomus saltatrix,* Bluefish. A-E. Development of scales through a size range of 12.5 to 37 mm. (*Silverman, M. J., 1975: fig. 1.*)

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Rachycentron canadum

cobias
Rachycentridae

FAMILY RACHYCENTRIDAE

The family Rachycentridae contains a single species, the cobia, *Rachycentron canadum*, which occurs in warm tropical seas throughout the world. It is found in shallow parts of the open ocean and is often associated with pilings, buoys, wrecks, or floating objects.

The cobia, which reaches an extreme length of about two meters, has an elongate, fusiform body; bands of small teeth on the jaws, vomer, palatines, and tongue; a long anal fin; and a series of 7–11 short, free spines in front of the dorsal fin. The caudal fin is forked in adults, round or truncate in juveniles.

Spawning may begin as early as April, and continues into August. The buoyant, pelagic eggs are of medium size (1.2 to 1.4 mm), and the yolk, which has been described as both granular and nongranular, contains a single large oil globule.

Hatchlings have not been described. Larvae are characterized by the rounded or truncate caudal fin; the long developing dorsal and anal fins; the position of the anus at about the midpoint of the body; and the presence of preopercular, supraorbital, and supratemporal spines by the end of the stage. Larvae from the Gulf of Mexico appear to be more heavily pigmented than similar-size specimens from the Mid-Atlantic Bight.

The head spines are all essentially lost by the time the young have reached 55 mm SL. In juveniles the caudal fin is distinctly rounded and enormously expanded, and there is a well-developed lateral pattern of light and dark stripes.

Rachycentron canadum (Linnaeus), Cobia

ADULTS

D. VII to IX–I to III,[13] 26 [16]–34; A. I [13] to III, 22–28; [16] C. 25; [24] P. 20–21; V. I, 5; gill rakers 7; branchiostegals 7; vertebrae 11–14.[28]

Proportions as times in SL: Depth 5.45 [15]–6.00; [24] head 4.0 [15]–4.96; distance from tip of snout to origin of first dorsal, 4.70, to origin of 2nd dorsal, 2.64; tip of lower jaw to ventral origin, 4.50. Proportions as times in head, eye 7.20.[24]

Body elongate, somewhat fusiform, only slightly compressed; caudal peduncle nearly round; head long, pointed, slightly depressed; eye small, round. Lower jaw projected, gape to front of pupil. Teeth small, in bands on jaw, vomer, palatines, and tongue.[6,9,12,15] Lateral line wavy and irregular, essentially parallel with back, but descending posteriorly.[12,25] Dorsal spines isolated; [8] caudal emarginate,[9] the upper lobe slightly longer; [12] pectorals broad, pointed.[25]

Pigmentation: Olive brown,[9] dark brown, or black above; [15] pale brown on sides with distinct dark lateral band bordered above and below with paler bands [9,12,26] (although lateral bands obscure in some specimens [8,18]); grayish white to silvery below. Dorsal and caudal dusky, anal and pelvics white, with gray or dusky markings, pectorals black.[12,15] Some individuals light, almost cream-colored throughout.[8]

Maximum length: Nearly 2 m in Senegal,[13] but in Western Atlantic 1778 mm.[9]

DISTRIBUTION AND ECOLOGY

Range: In Western Atlantic, Massachusetts to Argentina (35° S) and Bermuda; [4] also definitely recorded from the East Indies,[15] Ceylon,[16] Australia,[8] Japan,[24] and Senegal.[13]

Area distribution: Chesapeake Bay north to Patuxent River,[14,17] Chincoteague Bay, Virginia,[27] coast of New Jersey.[6]

Habitat and movements: Adults—an essentially solitary species, but sometimes in groups of 3 or 4 [8] or in schools; [13] found in open water in inlets, bays,[8,32] har-

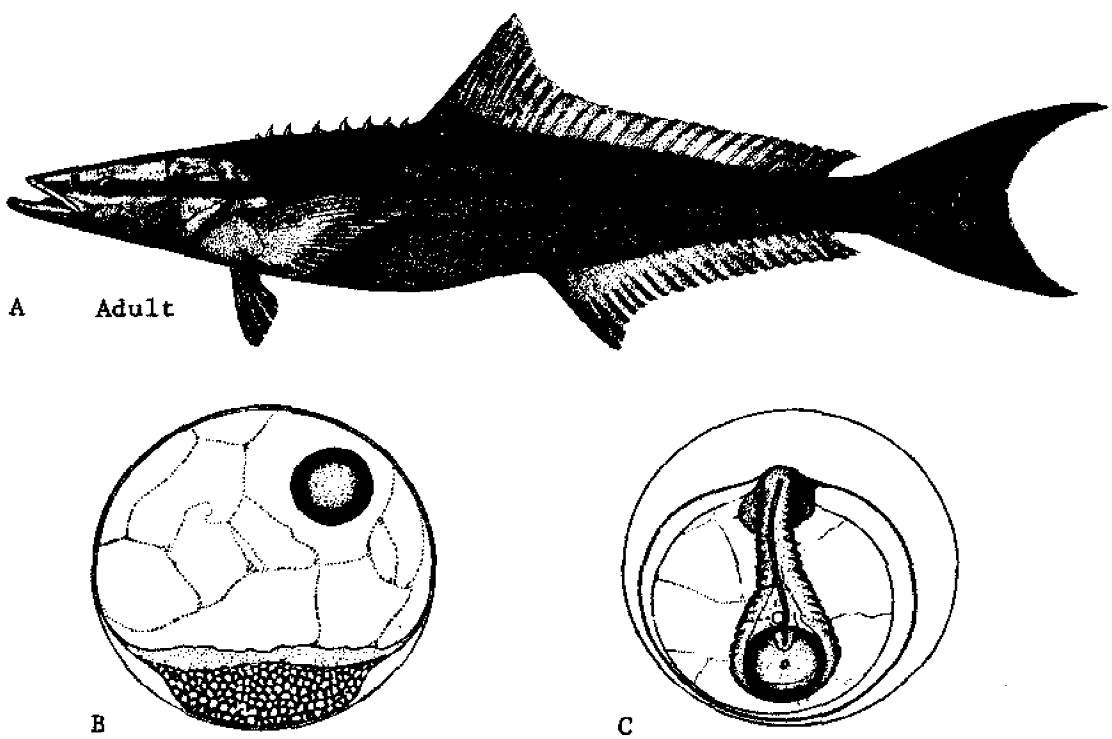

Fig. 225. Rachycentron canadum, Cobia. A. Adult, length unknown. B. Eggs, morula stage (note large oil globule and vesicular yolk). C. Eggs with advanced embryo, somites, Kupffer's vesicle formed. (A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 401. B, C, Ryder, J. A., 1887: pl. 3.)

bors,[25] and mouths of tidal creeks; also in vicinity of spits, reefs [14] (although rarely in clear-water reef areas [9]), bars,[14] and oyster beds,[25] and around pilings, buoys, and wrecks.[8] Sometimes associated with sharks and rays like pilot fishes.[23]

Migrate south from Chesapeake Bay in fall,[14] presumably to West Indies.[13,25] Inshore in Chesapeake Bay, May (when water temperatures reach 19.4–20.6 C) to October; [1,13,15] in South Carolina inshore from May to September; [18] in Georgia inshore to at least October; [2] appear on Texas coast in March and April; [35] inshore on Florida Gulf coast May through August.[33]

Larvae—specimens 13–15 mm SL, 40 to 64 km offshore in Gulf of Mexico; [28] specimens ca. 14 to 23 mm long at surface at night approximately 925 km off Delaware (JDH); specimens 7.0 mm long reported in "brackish water" in a coastal lagoon in India.[31] Recorded salinity range 27.8–37.7 ppt. Temperature range 23.9–32.0 C.[28]

Juveniles—along beaches,[3] in bays,[21,29,30] over shoals,[25] and around mouths of rivers; in surface water near or under floating objects; [7,13] also up rivers as, for example, Hudson River ca. 64 km to mouth of Croton River. Salinity range, from presumably freshwater (Hudson River) [22] to 44.5 ppt.[34] Recorded temperature range, 28 [3]–30 C.[34] Minimum depth, ca. 250 mm.[3]

Young "a few inches long" inshore in Gulf of Mexico in July and August; [26] specimens 45–50 mm long inshore in June in Texas.[10]

SPAWNING

Location: Possibly in lower Chesapeake Bay or in Atlantic Ocean in vicinity of Virginia Capes (in collections for 1960, 225 eggs were collected in Atlantic waters, 3 just inside mouth of Chesapeake Bay).[7,13]

Season: June, July, and August in Chesapeake Bay area, with individual females presumably spawning several time; [7,13] possibly late April and May in northern Gulf of Mexico.[28]

Fecundity: 1,935,000–5,439,000 ripe (or ripening) eggs; number of eggs per gram of ovary, 2300–3800, $\bar{x}=2600$.[14]

EGGS

Location: Pelagic,[5] usually in uppermost meter of water, and drifting with current; minimum salinity 23 ppt.[7]

Fertilized eggs: Diameter 1.16–1.42 mm, but with considerable seasonal variation (1.27–1.42 mm, $\bar{x}=1.34$ in June; 1.16–1.31 mm, $\bar{x}=1.21$ mm in July); [7] a single, refringent, large oil globule [5] (diameter 0.34–0.44, $\bar{x}=0.38$); [7] yolk described both as "broken into large irregular masses," [5] and nongranular; [7] perivitelline space narrow in early eggs, much wider in late eggs.[5]

EGG DEVELOPMENT

Development at unspecified temperature.[5]

Ca. 8 hours—epiboly complete.

Just prior to closure of blastopore—optic lobes, Kupffer's vesicle, somites formed.

Incubation period: 36 hours at unspecified temperature.[5]

YOLK-SAC LARVAE

No information.

LARVAE

Size range described, 12.6 [28]–24.3 mm (JDH).

Proportions expressed as times in SL (derived from values published by Dawson, JDH): Depth at anal origin 9.21–11.45; pelvic insertion to anal origin 3.26–4.12; head length 3.50–3.69.[28]

Larvae with a supracleithral spine, a supratemporal spine, a supraorbital spine, and a double series of preopercular spines. At 12.6 mm SL posterior preopercular series well-developed, the spine at the angle the longest.[28] At 14.6 mm SL teeth evident in upper jaw, appearing to be in more or less double row. Choroid fissure barely evident at 15.7 mm SL (JDH). At 12.6–12.9 mm SL dorsal finfold extended forward to short distance behind vertical from upper pectoral angle, preanal finfold to just behind pelvic insertion. Dorsal finfold still evident at 18.2 mm SL, preanal finfold evident only over posterior half of abdomen. In Gulf coast specimens some dorsal spines evident at 12.6–12.9 mm SL, but not in others at 13.6–13.7 mm; at 18.2 mm, 7 or 8 dorsal spines.[28] In Atlantic Coast specimens at 15.7 mm SL, 4 posteriormost dorsal spines barely evident; at 17.1 mm SL, 5 posteriormost dorsal spines; at 24.3 mm SL, 8 spines evident, but anteriormost barely developed (JDH). In Gulf coast specimens at 12.6–12.9 mm SL, caudal not greatly expanded, slightly emarginate, upper and lower lobes rounded, the lower lobe slightly longer.[28] Body covered with small bristles, each surmounted with several tiny hair-like structures. At 14.6 mm SL urostyle extended into caudal fin. Gut in 3 more or less equal length sections, the anterior 2 essentially opaque (in transmitted light), the posteriormost transparent and granular (JDH).

Pigmentation: In Atlantic coast specimens, at 14.6 mm SL a narrow dashed line of pigment mid-laterally; a distinct row of pigment along entire length of each side of anal base, extending on caudal base; a pale (light brown) band of visceral pigment; a broad, pale internal row of pigment behind eye which merges posteriorly with visceral pigment; a conspicuous cluster of melanophores in region of anus; belly and throat with few scattered small melanophores; scattered melanophores on pectoral base; small patches of melanophores on body above anus and below first half of dorsal fin; pectoral fin unpigmented; few melanophores on proximal half of median pelvic rays; dorsal fin unpigmented; anal with pigment on basal one-half anteriorly, extended to edge of fin posteriorly; caudal fin heavily pigmented on lower lobe, with pigment most dense on distal third of uppermost rays of lower lobe. At 15.7 mm SL, several large melanophores developed over brain. At 17.1 mm SL pelvic fins well pigmented, a conspicuous, dense, vertical bar of pigment near mid-point of caudal fin. At 24.3 mm SL pigment line along anal base less dense than in previous stages; several discrete groups of melanophores on body below dorsal fin, the groups occurring between every third or fourth myomere; pigment over brain greatly increased, and few scattered melanophores on back in front of dorsal; several median caudal rays and posterior anal rays densely pigmented (JDH).

In Gulf coast specimens, 12.6–12.9 mm SL, sides of abdomen with scattered, large brown melanophores; ground color pale, darkest below lateral line and on caudal peduncle; a broad, pale area across upper part of operculum to eye; head with scattered large melanophores; a pale median dorsal stripe; soft dorsal with few scattered, small melanophores near base; basal third of anal fin brown, distally pale, the dark pigment expanding outward to edge of fin posteriorly; pectorals pale, immaculate; pelvics pale with or without 3–4 minute brown streaks near insertion of median rays; caudal pale above, dark brown below except for fine pale margin on posterior and ventral margins. At 13.6–13.7 mm SL similar to previous stage but with increased pigmentation on dorsal, anal, and caudal fins. At 15.3 mm SL head and body densely marked with prominent melanophores, pale area on head somewhat reduced; pigment developing in pectoral fins; caudal fin no longer with pale ventral margin. At 16.6 mm SL an almost continuous line of single brown melanophores along bases of developing dorsal fins; basal 3rd of posteriormost 4–5 rays of dorsal with concentration of tan melanophores, remainder of dorsal fin pale; upper caudal fin with numerous scattered melanophores, ventral half of fin brown, margined with pale. At 18.2 mm SL body and head with dense scattering of large and small melanophores; body somewhat darker below midline; dorsal fin with narrow basal scattering of melanophores from near soft dorsal origin to last 6 or 7 rays where pigment expands to cover proximal two-thirds of remaining fin; pectoral base with few melanophores; pelvics with dense pigment except on two outer rays.[28]

JUVENILES

Minimum size described, 27.0 mm SL.

Proportions as times in SL at 27.0–55.0 mm SL: Depth at anal origin, 9.36–10.19; pelvic fin insertion to anal origin, 3.59–3.79.[28]

At 27 mm SL supracleithral and supratemporal spines essentially lost, supraorbital and anterior preopercular

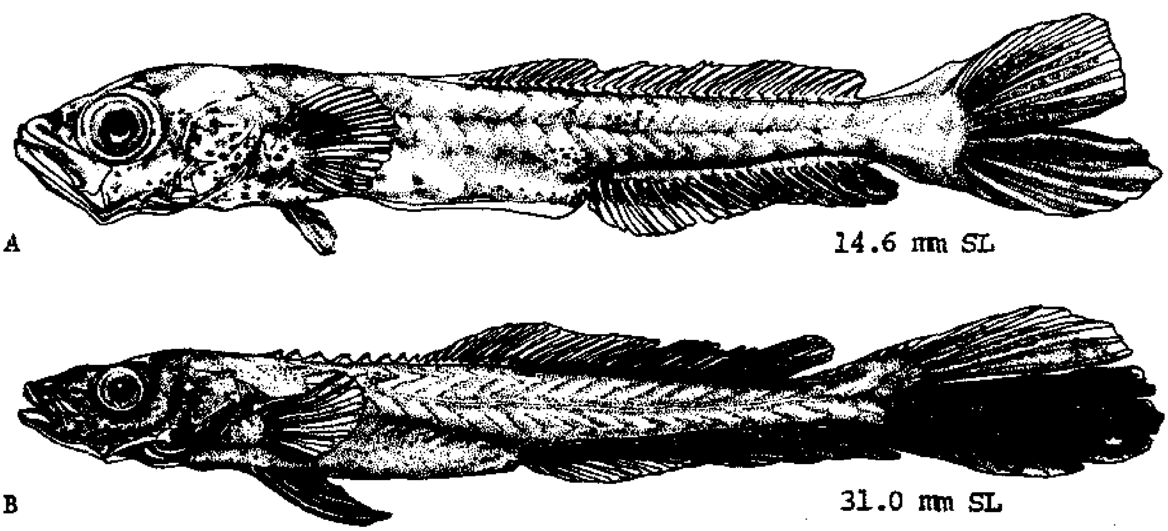

Fig. 226. *Rachycentron canadum*, Cobia. A. Late larva, 14.6 mm SL, preanal finfold still evident, preopercular spines prominent. B. Juvenile, 31.0 mm SL. (*A, B, Original illustrations, Elizabeth Ray Peters.*)

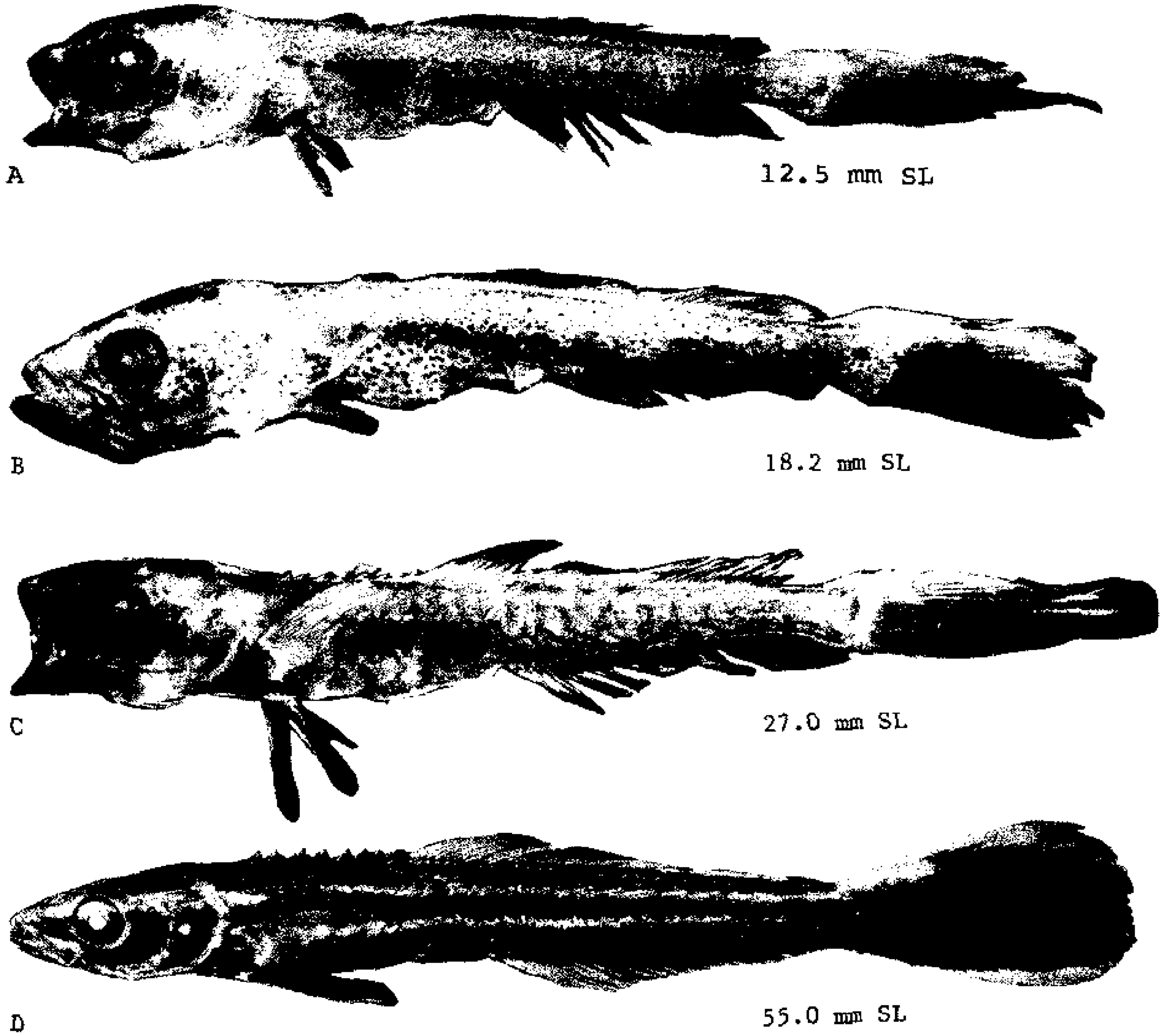

Fig. 227. *Rachycentron canadum*, Cobia. A. Larva, 12.5 mm SL. B. Larva or juvenile, 18.2 mm SL. C. Juvenile, 27.0 mm SL. D. Juvenile, 55.0 mm SL. *(A-D, Dawson, C. E., 1971: fig. 2.)*

series much reduced, posterior preopercular series with only three uppermost spines remaining. At 55 mm all spines lost or greatly reduced. At 27.0 mm SL "only fragments of dorsal finfold remain," preanal finfold completely lost at 44.3 mm SL. At 27.0 mm SL ventral half of caudal distinctly longer than upper half; at 55.0 mm SL caudal fin broadly rounded, but with 2 median rays slightly shorter than those above and below them and with lower lobe slightly longer.[28] Caudal also described as "much expanded and broadly rounded,"[7] and still rounded at ca. 100 mm.[20] Pectoral fins falcate at ca. 75 mm SL.[28]

Pigmentation: In Gulf coast specimens, at 27 mm SL sides brown and without large separated melanophores; a narrow, pale line with scattered melanophores along insertions of dorsal spines; chest and anteroventral abdomen pale with scattered melanophores; posterior part of abdomen with light median streak which expands to rather prominent subtriangular area around anus; spinous dorsal pale; melanophores on soft dorsal base beginning at 3rd ray; basal fifth of anterior part of anal fin brown, posterior part entirely brown; a small pale area on pectoral fin base; pelvic spine and outer ray pale, remainder of fin covered with dark brown melanophores; upper caudal fin pale proximally, with brown melanophores distally and ventrally; lower caudal mainly dark brown

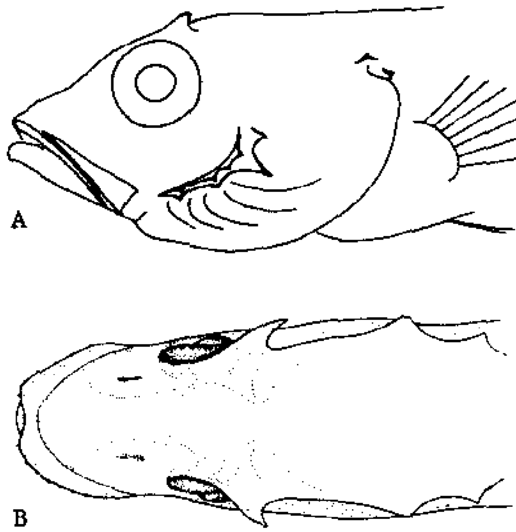

Fig. 228. *Rachycentron canadum*, Cobia. A. Lateral view of head, diagrammatic, showing spinations. B. Dorsal view of head of a specimen 14.6 mm SL (note tiny projecting teeth on upper jaw). (*A, Dawson, C. E., 1971: fig. 1. B, Original drawing, Daniel Carver.*)

with pale edge. At 44.3 mm SL with brownish ground color irregularly blotched with tan; soft dorsal margined with pale. At 55 mm SL body generally brown and with bands of silvery iridescence overlying ground color above and below a dull mid-lateral band; upper iridescent body band continued across opercle, preopercle, and posterior preorbital; chest and median ventral abdomen tan to pale with irregular concentrations of brown melanophores; soft dorsal pale distally with basal brownish band, broadest posteriorly; anal pale anteriorly, with basal brown band bordering posteriorly to edge of fin; pelvics dark brown with white edge on anterior margin; caudal predominately brown, darkest distally, with a light tan blotch on upper base and peduncle and with rather large pale crescents on upper and lower margins. At 65 mm dark lateral stripe distinct. At ca. 75 mm pectorals darkly pigmented. At ca. 130 mm pigment of pelvic fins and inner pelvic ray lost, fin typically white.[28]

In specimens from various localities, at 80 mm (in life) uniform jet black with two ill defined, iridescent (greenish brassy) lateral streaks running from snout to tail; edge of dorsal, anterior part of anal, and upper and lower edge of caudal white; pectorals transparent distally.[11]

A specimen ca. 83 mm long shows less contrast than other juveniles illustrated,[19] but this may have resulted from preservation.[7]

A specimen 98.4 mm long described as nearly black above, fading to dark green; a white stripe about as wide as pupil from upper angle of gill opening to caudal, and another narrower one from lower edge of caudal base to tail; upper caudal lobe edged with white, lower lobe with orange-red; belly grayish white; iris golden bronze.[6,20]

In a specimen of indefinite size (but probably over 100 mm, JDH), a black longitudinal band extending full length of body, bound above and below by sharply contrasting white bands; upper white band extended anteriorly onto head, passing just above eye (although illustration shows it through eye), and becoming diffuse on snout; dorsolateral light bands merge over caudal peduncle and extend onto caudal fin as a single band; ventrolateral light band from pectoral base to caudal fin; dorsal and ventral edges of caudal, margin of soft dorsal, anterior half of anal, and edges of pectorals white; pelvics uniform black.[7]

"Young" from Ceylon with one or two silvery lateral bands along lower part of brown upper coloration.[16] Black lateral band in young described as passing from snout through eye, to base of caudal.[15]

AGE AND SIZE AT MATURITY

Males mature in 2nd year, females in 3rd year; males at 517.2 mm FL, females typically at about 695.0 mm FL[13] (although a 426 mm female from India has apparently ripening ovaries[31]).

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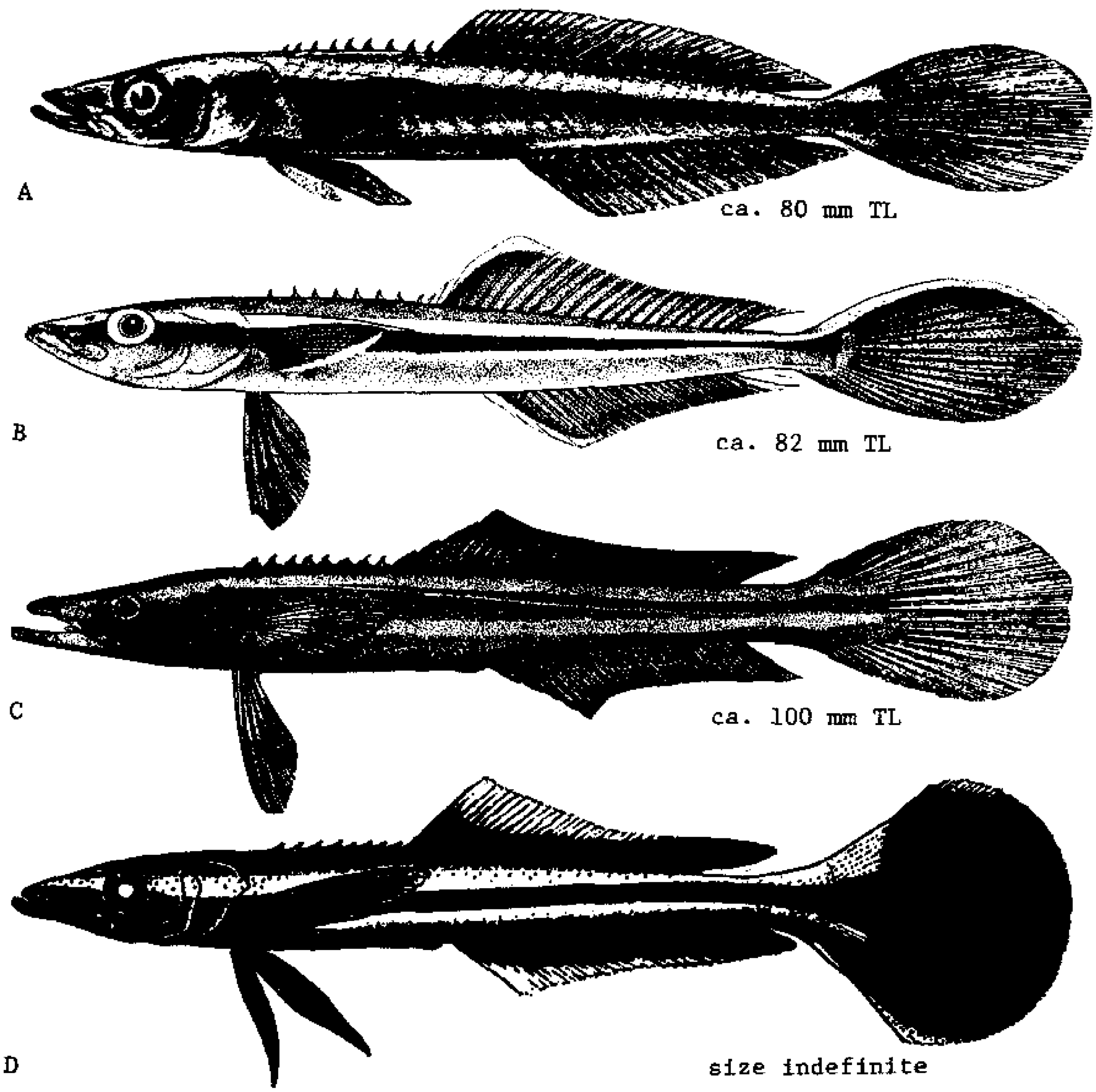

Fig. 229. ***Rachycentron canadum*,** Cobia. A. Juvenile, ca. 80 mm TL. B. Juvenile, ca. 82 mm TL. C. Juvenile, ca. 100 mm TL. D. Juvenile, size indefinite, composite illustration of specimens 108 and 120 mm TL. (*A, Breder, C. M., Jr., 1926: 180. B, Fowler, H. W., 1945: fig. 196. C, Bean, T. H., 1889: pl. 2. D, Joseph, E. B., 1964: fig. 3.*)

Fig. 230. *Rachycentron canadum*, Cobia. A. Juvenile, size unknown, specimen from Australia, showing development of emarginate tail (note additional ventral white stripe and forward extension of all white stripes onto head). (*A, Grant, E. M., 1972: 142.*)

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